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Wiggly Worms, homeless salamanders

Who would have thought that earthworms had a downside?

David Lee

Invasive species have been recognized as a leading cause in species' declines and extinctions (Clavero and García-Berthou. 2005.) and have specifically been credited for the global decline in amphibians (Klesecker 2003). When we hear about invasive exotic species problems we tend to think of the big and obvious cases: pythons invading the Everglades, or perhaps introduced rats eating the eggs of iguanas endemic to Caribbean islands. Most are aware of the role that exotic plants and animals play in competing with native species and changing ecosystems- multaflora rose taking over wetlands inhabited by bog turtles, or the displacement of native anoles by various introduced ones. But introduced earthworms would probably not be on most people's lists when it comes to discussing problematic ecological issues involving exotic species. Most would be surprised to learn that invasive exotic earthworms' ability to damage ecosystems has become a global problem. The invasive worms have spread through almost every type of habitat, including desert oases. And, except for Antarctica, they now occur on every continent and many oceanic islands.

We don't think much about worms because they all look more or less the same and they are usually out of sight. And worms are a good thing-Right? Gardeners, people composting, fishermen, students needing specimens for dissection, and robins feeding young all think of worms in positive ways. Their role in building and aerating soils is well known; this was first demonstrated in the early 1880s when Darwin showed that the worms on one acre of land can convert living and dead vegetation into 18 tons of productive soil in just twelve months.

Sixty of the 182 taxa of earthworms that occur in the United States and Canada are introduced. This represents about 33% of the total fauna (Blakemore 2006). The Lumbricidae are a family of large earthworms represented by such species as night crawlers (*Lumbricus terresteris*) and the Alabama jumper (*Amynthus agrestis*). Both are familiar to fishermen who use them for bait, and to students doing dissections in 10th grade biology classes. About 33 of the 670 of worms in this family have become naturalized around the world. Only two genera (*Eisenoides* and *Bimastos*) in this family are actually indigenous to North America (*Eisenoides lonnbergi* and most *Bimastos* spp.)

Introduced worms thrive in the absence of competitive native species. The Wisconsonian glaciation severely impacted the earthworms native to North America. In areas north of the glacial boundary the negligible population of native earthworms allowed the exotic invaders to flourish (Callaham 2008). Our native earthworms have worked their way back less than 100 miles north of this glacial line in the thousands of years since they were eradicated by ice sheets covering much of North America during the last glaciation.

The conservation issues

Under normal conditions it takes microbes and fungi three to five years to decompose a deciduous leaf to the point that it becomes incorporated into the soil. In a forest infested with introduced night crawlers, this process can take as little as four weeks (Mortensen and Mortensen 1998). The organic duff that covers a forest floor may take decades to accumulate, but can be consumed by introduced earthworms in short order. In temperate forests the ecosystem relies on the accumulation of undecayed and decaying leaf litter. Exotic earthworms decompose this leaf layer more rapidly than native ones, compromising the forest floor micro-habitats, making it unsuitable for seed germination and conditions unsuitable for the various creatures that are dependent of the leaf layer for foraging, humidity, and concealment. In addition to the loss of leaf litter there are marked changes in levels of moisture, temperature, pH, and nutrients. Subsequently the redistribution of organic matter and nutrient loss results in declines in native understory plant cover and an increase in nonnative plants. Soils are often exposed as every leaf, small seed, and tiny twig can be devoured by the introduced worms (see Nuzzo et al. 2009, Dourson and Dourson 2006 and Tennesen 2009). The soil exposure in turn leads to erosion. Hendrix et al. (2008) provide a good overview of the history of the exotic worms, discuss specific worms and describe the problems they cause. Publications in a wide variety of journals began to address the ecological consequences resulting from the introduction of non-indigenous worms (e.g., Bohlen, et al. 2004, Hale et al. 2005, Hendrix and Bohlen 2002, Suarez, et al. 2006) in the early 21st Century.

Research shows that when more species of nonnative earthworms appear in a site potential impacts are greater, especially to native plants. This results from the combination of different earthworms having different feeding and burrowing behaviors. When multiple exotic earthworm species are present the combined impact is greater than the sum of the effects of the individual species.

Worm introductions

Many of the harmful invasive earthworms now in the United States arrived in the 18th century. They were accidentally introduced in soil around bulbs and rootstocks of plants brought to the New World by Europeans wanting familiar species for gardens and landscaping. In more recent times additional species of worms were introduced from Europe and Asia and cultured on worm farms for use as fish bait. The annual global export of earthworms is a multimillion-dollar business. Species that are mass marketed are selected for their hardiness. The commercially available European and Asian worms are ones that can survive high latitude winters and can enter dormancy in response to high temperatures and low moisture. Unlike many of our native species these exotic worms are tolerant of disturbed habitats, and additionally a number of them are parthengenectic and have high reproductive rates. For many species a single worm can establish a population. Collectively these factors greatly enhance their chance of becoming established (James and Hendrix 2004).

As early as the 1960s it was recognized that exotic earthworms were becoming established in forests from fishermen dumping unused bait. Nonetheless, prior to the last few decades these worms were apparently uncommon in undisturbed forests. These exotic worms are also moved about by construction as soil is moved from one site to another. They can even be transported in the mud on tires of trucks. This has particularly become a problem with logging trucks. Perhaps

related is the ability of some species to take over areas that have been clear-cut. Livestock can likewise translocate the worms when cocoons (egg cases) are carried in mud stuck in the hooves of animals. The main issue today remains fishermen discarding unused bait, often along streams deep in the interior of undisturbed forest. To add to the problem, a wave of Asian species sold for bait is currently progressing through North America (James and Hendrix 2004). In Canada as well as in a number of northern states the loss of leaf debris on the forest floor can be seen radiating out from boat landings, the edges of lakes and other places where people fish, indicating a strong correlation between recreational fishing activity and changes in the forest floor and understory.

The timing and success of these serendipitous introductions is difficult to measure because in most instances there is no way to determine when, or how may, worms were released. And, of course, many sites have had multiple introductions. Soon after I first moved to North Carolina my neighbor across the road started a "worm ranch." He ran a small country store and because of the store was located near a recently impounded reservoir fishing supplies became an important part of his business. Soon after the reservoir was completed he invited me over to see his worm ranch, a series of wood-lined beds with rich soil into which he poured compost. Every few months he would give me a worm report; he was pleased with his results. Several years into his operation we had a summer of hellaceous rains. His worms escaped and he eventually gave up on his enterprise. For months I was finding large earthworms crawling across the surface of my driveway, and everything in my yard had dozens of worms hiding under it. This was a hundred to two hundred yards from their site of escape and I have no idea how much further the army of night crawlers dispersed. I suspect that a few bait worms dumped out by fishermen would have similar, though not as dramatic, dispersal skills.

The impact on Salamanders

Invasive earthworms alter the forest community, changing the flow of nutrients and energy, and ultimately the populations of terrestrial salamanders. The impact to woodland salamander populations appear to be four fold. First, the consumption of the leaf litter in deciduous forests takes away the primary foraging areas for both young and adult salamanders. Not only does it remove cover, but this changes the humidity levels on the forest floor. Second, the salamanders' prey base is greatly diminished because of the decline in the numbers and types of invertebrates dependent on this microhabitat. The larger exotic earthworms brought into the forest interiors by fishermen out-compete native species and they are too large for consumption by young, and immature salamanders. This leads directly to a collapse of the populations. Third, over time changes resulting from the loss of leaf litter eliminates ferns and other native woodland plants and allows further spread of exotic species, making the community even less suitable for woodland salamanders. Fourth, siltation resulting for the loss of ground cover in many cases would be harmful to the eggs, larva, and prey base of aquatic stream-dwelling salamanders.

In the one study to date to demonstrate the role of exotic earthworms on salamander populations Maerz et al. (2009) showed that earthworms pose a significant threat to woodland salamander populations of the northeastern states. In a mark-recapture study they tracked salamander abundance across plant invasion fronts at 10 New York study sites to determine if reductions in salamander abundance was driven by shifts in the understory plant community or by the worms. The salamander abundance decreased exponentially with decreasing leaf litter resulting from the invading earthworms. There was a strong correlation between salamander prey abundance (excluding non-native earthworms) and the volume of leaf litter. Their analysis showed there was no relationship between invasive plant cover and salamander abundance. The plant invasions are symptomatic of degraded amphibian habitats but were not the driving force behind declines in salamander populations. The invasion of non-native plants were facilitated by exotic earthworm invasions. The study

showed that at four sites, except for earthworms, that small arthropods and other prey declined in abundance with the loss leaf litter. The non-native plant invasions were symptomatic of degraded habitat, but in themselves do not directly drive the habitat degradation.

The primary species that became the focus of the Maerz et al. (2009) study was the red-backed salamander (*Plethodon cinereus*) in that it accounted for 80-90% of the salamanders encountered in their study sites. Other species in their study included the northern slimy salamander (*P. glutinosus*) Allegheny mountain dusky salamander (*Desmognathus ochrophaeus*), northern two-lined salamander (*Eurycea hislineata*), four-toed salamander (*Hemidactylium scutatum*), northern spring salamander (*Gyrinophilus porphyriticus*), northern red salamander (*Pseudotriton ruber*), spotted salamander (*Ambystoma maculatum*), and the eft stage of the eastern red-spotted newt (*Notophthalmus viridescens*).

Our eastern North American salamander fauna represents the greatest biodiversity of these amphibians in the world, with the assemblage in southern Appalachian region being by far the highest in the world. The exotic earthworm *Amynthas agrestis* has colonized portions of the Great Smoky Mountains National Park. Researchers found that the worm colonies are mobile, especially when soils are wet and after rain (Callaham 2008, Callaham et al. 2006). The presence of exotic earthworms in the park is particularly troublesome because of the high rate of salamander endemicism in the region.

In the Maryland area one can anticipate that woodland salamanders (*Phethodon*), the terrestrial stage of newts (*Notophihalmus*) and mole salamanders (*Ambystoma*) to be the ones most impacted. Among these salamanders special mention should be made of the eastern tiger salamander (*Ambystoma t. tigrinum*) as it is endangered in Maryland, as well as most other states where it occurs. The one major historical site where it is still known to occur in Maryland is within a state wildlife management area where the ponds are stocked with bass and bluegills for fishermen (Lee 2006). Not only are these non-native fish aggressive predators, but enticing people to fish in this area is a guaranteed recipe for exotic worms to be introduced into a region where endangered salamanders are dependent on leaf litter for shelter and foraging. The root of this problem is not unique to Maryland, most state nongame programs are under department of natural resources agencies. These are agencies that were first put in place to see to oversee the needs of hunters and fishermen. The agency is staffed and run primarily to address the needs of fish and game species and much of their annual budgets come from the sale of hunting and fishing licenses. Nongame species are seldom of primary concern.

Of course the invasions of non-indigenous worms are also affecting a broad spectrum of other woodland species. Concerns have been expressed for ground roosting bats (Brack et al. 2013) ground foraging nesting birds (Loss et al. 2012), the leaf litter community [i.e., springtails (Migge-Kleian et al 2006), millipedes (Snyder and et al.2009), and other arthropods (Burke et al. 2011) as well as terrestrial snails (Dourson and Dourson 2006)], and shifts in the community structure of forest floor plants (Larson et al. 2010, Szlavecz et al. 2011). In addition the changes in the leaf litter results in loss of mycorrhizal fungi (Lawrence et al 2003), and paves the way for the establishment of exotic plants (Frelich et al. 2006). Most of our native understory woodland flora requires a deep, rich, and fertile layer of leaf litter for germination. Woodland ferns and spring wildflowers such as bellworts, trilliums, yellow violets and wild ginger die out and exotics plants like garlic mustard become established. Shifts in the community structure of many of these organisms could likewise have indirect impacts on our terrestrial salamanders.

While the introduced worms can be eaten by the adults of some species of salamanders, most are too large for juvenile salamanders and eventually this leads to a net loss in the salamander

population. An additional concern is the possibility of lead transfer from non-indigenous earthworms to their predators. This has been demonstrated to occur in both amphibians (Ireland 1977) and small mammals (Reinecke et. al 2000).

Listing all the issues facing salamanders and other amphibians- habitat loss, especially in wetlands, as well as road mortality, collection for pet trade, introduced predators. siltation, pollution, pesticides, acid rain, climate change, chytrid fungus (*Batrachochytrium dendrobatidis*) , and Ranaviruses- now includes exotic worms. Who could have predicted this? They are just lowly worms for Christ sake. While most people can understand the direct consequences of development, overexploitation, or pesticide pollution, our subtle and unintended activities can also take a toll.

So what can be done about all this? The answer is not much. The trick would be finding a solution that would target the introduced invasive earthworms and not harm our native ones; after all the indigenous earthworms are an important component of many of our natural communities. This problem has only recently come to light and our land use agencies are still in the phase of documenting the damage. Callaham et al. (2006) provide policy and management guidelines and the University of Minnesota has established a web site that offers a suggestions for stopping the continued spread of the alien worms (http://www.nrri.umn.edu/worms/team/action.html). Preventing introductions is the best protection, but in many areas exotic worms are already well established. As of now there are no good tools to target the worms, and at present their eradication is not economically feasible. There are many pesticides, herbicides and fungicides that are toxic to the introduced earthworms, but they are also toxic to native worms and other forest soil organisms. Biological controls probably are not an option, introducing one exotic species to deal with another exotic is unwise and there are numerous examples that reinforce the foolishness of such options.

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David S. Lee, The Tortoise Reserve, PO Box 7082, White Lake, NC 28337, torresinc@aol.com

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Lack of Sexual Size Dimorphism in *Sceloporus poinsettii* from Durango, Mexico

Abstract.

We examined sexual size dimorphism in a population of *Sceloporus poinsettii* from Durango, Mexico. We found no evidence for sexual dimorphism in body size, head size, or femur length in this population. Our results, in combination with other studies on sexual dimorphism in *S. poinsettii*, suggest that there is within-species variation in the extent of sexual dimorphism.

Lizards in the genus *Sceloporus* have long been the subject of interest in studies of sexual size dimorphism (SSD; see Fitch, 1978 for an early review and discussion). Despite this interest, we still know relatively little about variation in SSD among species and among populations of the same species, especially in the species of *Sceloporus* from Mexico. Ramírez-Bautista et al. (in press) recently reviewed SSD of lizards in the *spinosus* group/*formosus* group clade of *Sceloporus* and found variation in the presence of SSD within the clade, within each species group, and even within species. Smith et al. (2003) found no variation in SSD between two populations of *S. ochoterenae*, as did Ramírez-Bautista et al. (2008) in two populations of *S. minor*, except for differences in sexual dimorphism in tibia length. These results suggest that we need a greater database on SSD in *Sceloporus* to more fully understand the extent of variation in sexual dimorphism among and within species.

Here we report on sexual dimorphism in SVL, head size (width and length), and femur length of a population of *Sceloporus poinsettii* from Durango, Mexico. Despite numerous studies on the ecology and biology of this species (see Webb, 2008 for review), we know very little about the extent of its sexual dimorphism. Ballinger (1973) reported that maximum size of males was larger than that of females in a population from Texas. Fitch (1978) found males were significantly larger than females in a mixed sample of *S. poinsettii* from Chihuahua, Coahuila, and Texas. Similarly, Gadsden et al. (2005) found that male *S. poinsettii* were larger than females in a population from Mapimí in Durango, Mexico. We are not aware of any studies on sexual dimorphism in head size or femur length in *S. poinsettii*.

Materials and Methods

We captured lizards by hand on 6 August 1997 at a locality 7.5 km S jct. 40/49, S of Cuencamé, Durango on Hwy 40 (24° 49' 13.90" N, 103° 44' 17.43" W, 1761 m asl) and on 7 August 1997 at a locality 1.6 km NE Francisco I. Madera, Durango along Hwy 40 (24° 24' 17.65" N, 104° 17' 47.24" W, 1993 m asl). For analyses, we pooled individuals from both localities. We measured various morphological traits on each captured lizard to assess sexual dimorphism in these structures. We measured snout-vent length (SVL), head width (HW; at the widest point), head length (HL; from anterior edge of ear to tip of snout), and femur length (FL; from knee to middle of pelvic region) to the nearest 0.01 mm using calipers.

We conducted two sets of analyses. First, we analyzed data from all individuals. Second, we ran the analyses on a restricted subset of the data limited to the largest 10 individuals of each sex to account for any possible effects of greater numbers of smaller individuals (i.e., juveniles) in one sex or the other (see Andrews and Stamps, 1994). Sexual dimorphism in SVL and trunk size (SVL – HL) were analyzed using analysis of variance. Sexual dimorphism in HW, HL, HW/HL ratio and FL was analyzed using analysis of covariance with SVL as the covariate (all four variables were significantly influenced by SVL, except for HW/HL ratio in the restricted analysis so

an ANOVA was used in that case). Unless noted, the slopes in the ANCOVAs were homogeneous and interaction terms removed from the final model. Means are given ± 1 SE.

Results

Full analyses.—Largest male was 118 mm SVL (range = 44 – 118 mm) and the largest female was 111 mm SVL (range = 43 – 111 mm). Male and female *S. poinsettii* did not differ in SVL (Table 1; $F_{1,37} = 0.51$, $P = 0.82$). Trunk length (SVL – HL) also did not differ between males and females (Table 1; $F_{1,37} = 0.50$, $P = 0.82$).

Head width did not differ between the sexes (Table 1; $F_{1,36} = 0.12$, $P = 0.72$), and increased with SVL ($F_{1,36} = 941.6$, $P < 0.0001$). Male and female *S. poinsettii* had similar mean head lengths (Table 1; $F_{1,36} = 0.0014$, $P = 0.97$), and that trait increased with SVL ($F_{1,36} = 1299.3$, $P < 0.0001$). The ratio HW/HL did not differ between males and females (Table 1; $F_{1,36} = 0.11$, $P = 0.74$), but decreased with SVL ($F_{1,36} = 29.31$, $P < 0.0001$). Femur length did not differ between males and females (Table 1; $F_{1,36} = 0.037$, $P = 0.85$), but increased with SVL ($F_{1,36} = 887.1$, $P < 0.0001$).

Restricted analyses.— Males in the restricted analysis ranged from 88 to 118 mm SVL, and females ranged from 90 to 111 mm SVL. The SVL of male and female *S. poinsettii* did not differ (Table 1; $F_{1,18} = 0.50$, $P = 0.49$). Trunk length (SVL – HL) of males and females also did not differ (Table 1; $F_{1,18} = 0.59$, $P = 0.45$).

Head width did not differ between the sexes (Table 1; $F_{1,17} = 0.27$, $P = 0.61$), and increased with SVL ($F_{1,17} = 37.0$, $P < 0.0001$). The mean head lengths of male and female *S. poinsettii* were similar (Table 1; $F_{1,17} = 0.31$, $P = 0.58$), and increased with SVL ($F_{1,17} = 57.2$, $P < 0.0001$). The ratio HW/HL did not differ between males and females (Table 1; $F_{1,18} = 1.31$, $P = 0.27$). Mean femur length was not different between the sexes (Table 1; $F_{1,17} = 0.24$, $P = 0.63$), and increased with SVL ($F_{1,17} = 40.7$, $P < 0.0001$).

Table 1. Means (SVL, Trunk Length, HW/HL ratio in restricted analysis) and least squares means (Head length, Head width, HW/HL ratio in full analysis, and femur length) of male and female *Sceloporus poinsettii* from Durango, Mexico. Means are given ± 1 S.E.

	Male	Female
Full analysis ($N_{male} = 18$; $N_{female} = 21$)		
SVL	84.9 ± 5.2 mm	83.3 ± 4.8 mm
Trunk length	65.6 ± 4.0 mm	64.4 ± 3.8 mm
Head length	19.1 ± 0.2 mm	19.1 ± 0.2 mm
Head width	18.0 ± 0.2 mm	17.9 ± 0.2 mm
HW/HL ratio	0.95 ± 0.01	0.95 ± 0.01
Femur length	22.9 ± 0.3 mm	23.0 ± 0.3 mm
Restricted analysis ($N_{male} = N_{female} = 10$)		
SVL	101.8 ± 3.2 mm	99.1 ± 2.0 mm
Trunk length	78.8 ± 2.8 mm	76.4 ± 1.6 mm
Head length	22.7 ± 0.3 mm	22.9 ± 0.3 mm
Head width	21.1 ± 0.3 mm	20.9 ± 0.3 mm
HW/HL ratio	0.93 ± 0.01	0.91 ± 0.01
Femur length	27.6 ± 0.4 mm	27.4 ± 0.4 mm

Discussion

There was no evidence of sexual size dimorphism (body size, head size, femur length) in the population of *Sceloporus poinsettii* we sampled in Durango, Mexico; except that the largest male was larger than the largest female. Our results contrast with previous observations of sexual size dimorphism in SVL in *S. poinsettii* (Fitch, 1978; Gadsden et al., 2005). However, Fitch (1978) placed *S. poinsettii* in a group that had no consistent patterns of sexual size dimorphism (his Group III, subgroup D). Taken together these results suggest that the extent of sexual dimorphism can vary among populations of *S. poinsettii*. Such a finding is consistent with the conclusion that sexual dimorphism is a plastic trait in *Sceloporus*, as has been suggested in a previous review (e.g., Ramírez-Bautista et al., in press). It is clear that additional data from more populations and species of *Sceloporus* are needed before we can gain a full understanding of the extent of variation in sexual size dimorphism and the potential phylogenetic and ecological correlates of such variation.

Acknowledgments

This study conformed with the laws and regulations in place in Mexico at the time it was performed.

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Julio A. Lemos-Espinal [1], Laboratorio de Ecología. UBIPRO, FES Iztacala, Universidad Nacional Autónoma de México, Av. De los Barrios # 1, Col. Los Reyes Iztacala, Tlalnepantla, Estado de México, México.

Geoffrey R. Smith, Department of Biology, Denison University, Granville, Ohio 43023 USA.

John B. Iverson, Department of Biology, Earlham College, Richmond, Indiana 47374 USA

Juan Manuel Morales Sandoval, Laboratorio de Ecología. UBIPRO, FES Iztacala, Universidad Nacional Autónoma de México, Av. De los Barrios # 1, Col. Los Reyes Iztacala, Tlalnepantla, Estado de México, México.

[1]Corresponding Author: lemos@unam.mx

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Ecology of a Terrestrially Active Salamander Assemblage in a Northern Allegheny Forest

Abstract.

Systematic collections during 2008-2009 and opportunistic collections during 2006-2010 provided us with data to examine terrestrial seasonal activity and reproductive aspects of four salamanders on the Powdermill Nature Reserve (PNR) in the northern Allegheny Mountains of southwest Pennsylvania. Results from our study were restricted to the most terrestrially active of the salamanders inhabiting the site. The dominant species in our study was the Allegheny Dusky Salamander, *Desmognathus ochrophaeus*, which likewise dominated terrestrial captures at most sites in a study conducted elsewhere on the station in the early 1980s. Seasonal patterns in terrestrial activity, assemblage structure, and reproductive data from our study in part test earlier findings of salamander terrestrial ecology on the PNR and provide novel data, both of which are necessary for effective resource management of a maturing northern Allegheny Mountain forest community.

Introduction

The Powdermill Nature Reserve (PNR) is an 890.3 ha nature reserve located in the Ligonier Valley along the Laurel Ridge of the Allegheny Mountains in Westmoreland County of southwestern Pennsylvania and is owned and operated by the Carnegie Museum of Natural History (CMNH) (Meshaka et al., 2008). The PNR was founded in 1956 by Dr. M. Graham Netting, Director of the CMNH (Meshaka et al., 2008). In part, what had been former farmland, the PNR contains a mix of forests, thickets streams, vernal pools, artificial ponds, and fields.

A herpetofuaunal list for the PNR recorded 39 species of amphibians and reptiles, among which 35.9% (n = 14) were salamanders (Meshaka et al., 2008). Twelve species of salamanders were recorded on the PNR using pitfall traps in an earlier study during 1981-1982 (Meshaka, 2009). The number of salamander species reported on the PNR was lower than that of Westmorland County (n = 17) and represented 60.9% of the 23 species of salamanders known from Pennsylvania (Meshaka and Collins, 2012).

Assemblage structures of salamanders on the PNR was based on terrestrial movements during 1982-1983 from captures in 66 arrays at seven sites that encompassed primarily mixed deciduous forests of varying elevations and ground surface moisture levels as well as a field (Meshaka, 2009). The Allegheny Dusky Salamander *(Desmognathus ochrophaeus)* was overwhelmingly the dominant salamander species in all but the two sites not near standing water, where it was less abundant than the Northern Redback Salamander *(Plethodon cinereus)* in the field and less abundant than both the Northern Redback Salamander and the Red-spotted Newt *(Notophthalmus viridescens viridescens)* in a drier forest (Meshaka, 2009).

None of the arrays of this earlier study were placed in the expansive section of beech-maple floodplain habitat of the eastern section of the property. The section is low and flat and had yet to be examined with respect to the assemblage structure of its salamanders as determined by their terrestrial movements. For this reason, we conducted a study in the northwestern section of the PNR with the primary goal of comparing our findings with those analyzed from sites elsewhere on the property during 1982-1983 (Meshaka, 2009) and secondarily to provide life history data for this segment of the fauna inhabiting the northern Allegheny in general and the PNR in particular.

Site Description and Materials and Methods

The study was conducted in an approximately 5,000 m2 section of mixed deciduous mesic forest (Figure 1) located in the northeastern section of the PNR between Stony Lonesome Road and Route 381. Characterized as a beech-maple flood-plain, it has significant components of *Prunus, Betula, Carpinus, Ostria, Liriodendron, Carya, Platanus, Quercus,* and *Nyssa.* The areas at the site and nearby have been under closed canopy of large trees for more than 80 years (1939 aerial photography in witness). Ample vernal pools and seeps with no fish are present at the site as are a lot of old rotting logs on the ground. Human impact in the last 50 years has largely been limited to foot traffic on trails (John Wenzel, pers. comm.).

Diurnal searches of 0.5 hr duration were conducted by the senior author once each month during May-October of both 2008 and 2009. Opportunistic diurnal collections of salamanders were made during 2006-2010. Searches generally occurred during one day but were occasionally split between two days. All salamanders, as well as other amphibians and reptiles captured from searches under natural cover, were euthanized immediately and fixed in 10% formalin for at least one week before being transferred to 70% denatured alcohol and deposited in the Section of Zoology and Botany of the State Museum of Pennsylvania.

Subsequently, snout-vent length (SVL) of each specimen was measured to the nearest 0.1 mm with hand calipers. Dissections of each specimen provided information on sex and reproductive condition. Length and width of the central portion of the testis and diameters of ovarian follicles were measured to the nearest 0.1 mm using a dissecting scope with an ocular micrometer. Counts

Figure 1. The beech-maple flood plain that comprised the research site of this study at the Powdermill Nature Reserve, Westmoreland County, Pennsylvania. Photograph by W.E. Meshaka, Jr., on 17 August 2011.

of enlarged follicles were used to estimate clutch size. All statistical analyses were performed using Excel, t-tests were two-tailed, and statistical significance was recognized at $p < 0.05$.

Results

Species Account-*Desmognathus ochrophaeus* Cope, 1859- With 105 captures of 50 males, 33 females, and 22 juveniles, the Allegheny Dusky Salamander comprised 65.0% and 80.5% of all amphibians captured during May-October of 2008 and 2009, respectively (Figure 2). Seasonal activity of all individuals combined and of males was bimodal, with peak periods of surface activity in May and August (Figure 3). Females were most active at the surface in May followed by a slow decline thereafter. Juveniles appeared to be most active in May and September but these conclusions are tentative in light of the small sample size (Figure 3).

Among all adults collected during 2006-2010, the mean body size of 70 adult males (mean = 39.0 ± 3.01 mm SVL; range = 33.0-46.7) was significantly ($t = 2.275$, $df = 106$, $p = 0.03$) larger than that of 38 adult females (mean = 37.7 ± 2.59 mm SVL; range = 33.7-42.4). Twenty-seven juveniles ranged 15.5-32.6 mm SVL. Various stages of follicular development were present throughout much of the sampling period (Figure 4). The largest follicles of ≥ 2.9 mm were detected in spring. The next largest size range of follicles of ≥ 2.0 mm were present in all but females collected in July (Figure 4). These monthly size distributions of follicles were indicative of nesting throughout much of the sampling period. Clutch sizes of 18 females (mean = 39.7 ± 3.04 mm SVL; range = 33.9-46.6) ranged 12-45 eggs (mean = 24 ± 10.87) and was positively associated with the

Figure 2. Assemblage composition of the 142 captures of four terrestrially active salamander species in a mixed deciduous hardwood forest at the Powdermill Nature Reserve, Rector, Westmoreland County, Pennsylvania, during May-October 2008-2009.

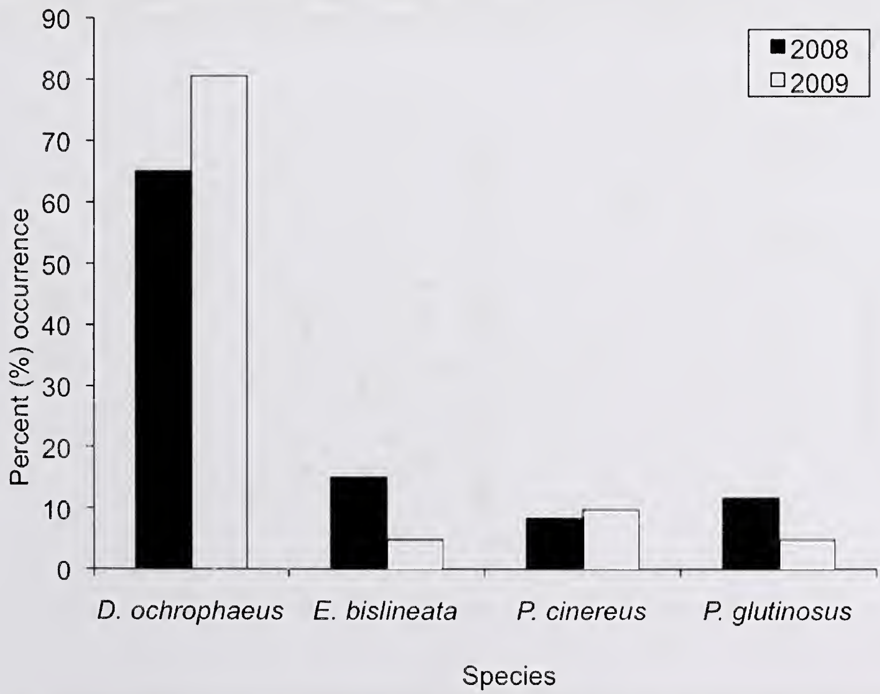


Figure 3. Monthly surface activity of 50 male, 33 female, and 22 juvenile Allegheny Dusky Salamanders *(Desmognathus ochrophaeus)* at the Powdermill Nature Reserve, Rector, Westmoreland County, Pennsylvania, during May-October 2008-2009.

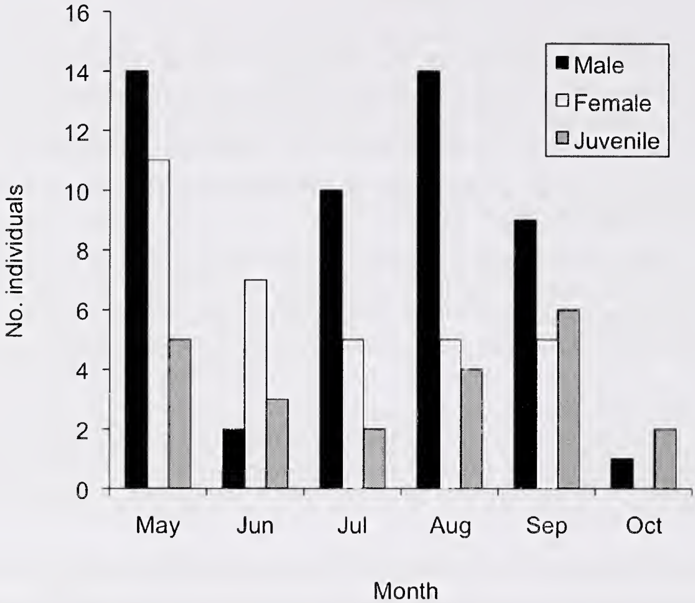
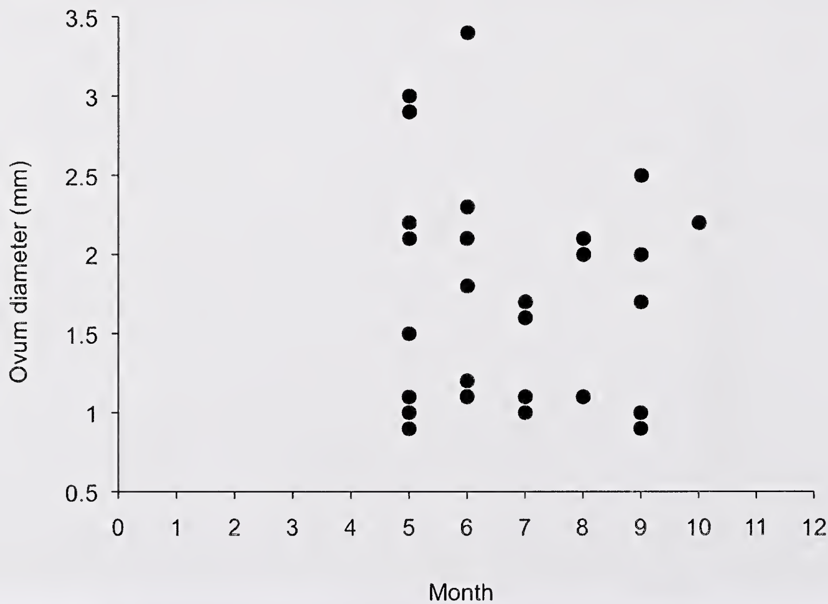


Figure 4. Monthly distribution of follicle size in 18 Allegheny Dusky Salamanders *(Desmognathus ochrophaeus)* at the Powdermill Nature Reserve, Rector, Westmoreland County, Pennsylvania, during 2006-2010.



body size of the female (Figure 5). The smallest individual was caught in July and measured 15.5 mm SVL (Figure 6).

Eurycea bislineata (Green, 1818)- With 13 captures of seven males, five females, and one juvenile, the Northern Two-lined Salamander comprised 15.0% and 4.9% of all salamanders captured during May-October of 2008 and 2009, respectively (Figure 2). Too few individuals were captured to ascertain sex or age-specific amplitudes in seasonal activity (Figure 7).

Among all individuals collected during 2006-2010, the mean body size of 10 adult males (mean = 38.6 ± 5.40 mm SVL; range = 28.9-43.8) was not statistically different (t-test, p> 0.05) than that of seven adult females (mean = 41.9 ± 3.24 mm SVL; range = 36.4-46.6). Three juveniles measured 26.0, 26.9, and 30.5 mm SVL. Clutch sizes of five females (mean = 42.6 ± 2.55 mm SVL; range = 40.5-46.5) ranged 35-45 eggs (mean = 39.8 ± 5.01).

Plethodon cinereus (Green, 1818)- With 13 captures of two males, six females and five juveniles, the Northern Redback Salamander comprised 8.3% and 9.8% of all salamanders captured during May-October of 2008 and 2009, respectively (Figure 2). Seasonal activity of this species was distinctly bimodal with peak periods of surface activity in May and October with too few individuals to ascertain sex or age-specific amplitudes in seasonal activity (Figure 8).

Among all individuals collected during 2006-2010, mean body size of five adult males (mean = 37.1 ± 2.90 mm SVL; range = 33.2-40.8) was significantly smaller (t = 2.601; df = 13; p < 0.02) than that of 10 adult females (mean = 42.1 ± 3.70 mm SVL; range = 37.4-46.3). Nine juveniles ranged 27.6-33.9 mm SVL. Body sizes of three females and their clutch sizes were as follows: 41.6

Figure 5. The relationship between estimated clutch size and female body size in 18 Allegheny Dusky Salamanders *(Desmognathus ochrophaeus)* at the Powdermill Nature Reserve, Rector, Westmoreland County, Pennsylvania, during 2006-2010.

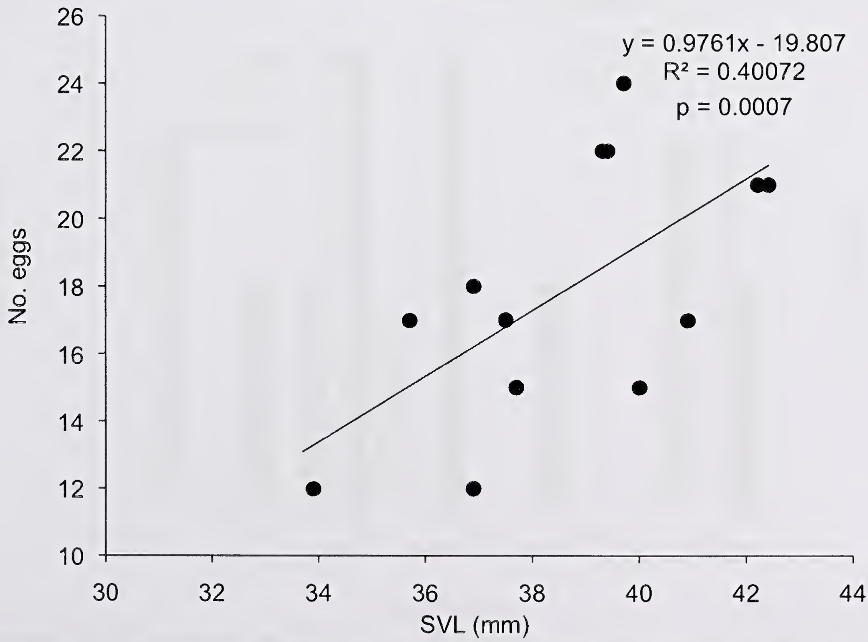


Figure 6. Monthly distribution of body size in 70 male, 38 female, and 27 juvenile Allegheny Dusky Salamanders *(Desmognathus ochrophaeus)* at the Powdermill Nature Reserve, Rector, Westmoreland County, Pennsylvania, during 2006-2010.

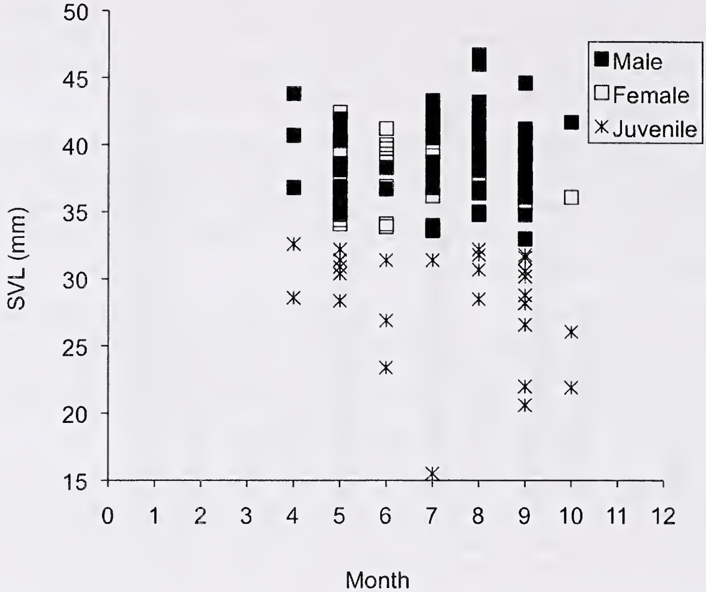
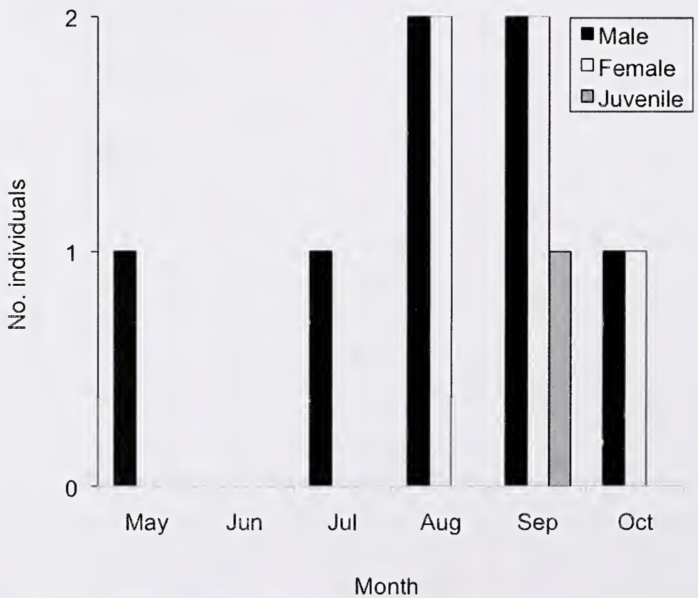


Figure 7. Monthly surface activity of seven male, five female, and one juvenile Northern Two-lined Salamanders *(Eurycea bislineata)* at the Powdermill Nature Reserve, Rector, Westmoreland County, Pennsylvania, during May-October 2008-2009.



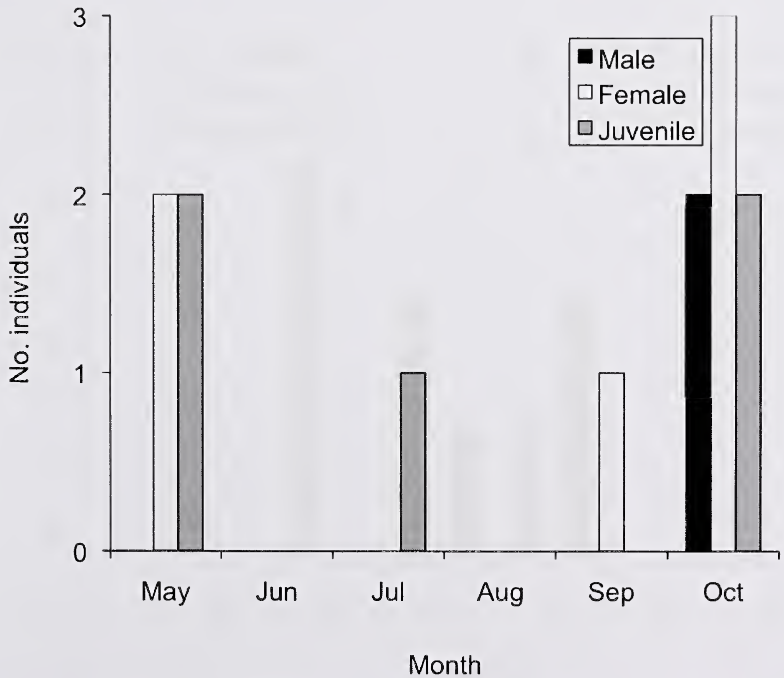
mm SVL (11 eggs), 45.5 mm SVL (11 eggs), 46.3 mm SVL (8 eggs). Four of 24 individuals had bobbed tails, and two additional individuals had regenerated tails. All individuals of this sample were of the dorsally-striped morph.

Plethodon glutinosus (Green, 1818)- With 11 captures of three males, two females, and six juveniles, the Northern Slimy Salamander comprised 11.7% and 4.9% of all salamanders captured during May-October of 2008 and 2009, respectively (Figure 2). Seasonal activity of this species appeared to be unimodal, with too few individuals to ascertain sex or age-specific amplitudes in seasonal activity (Figure 9).

Among all individuals collected during 2006-2010, mean body size of seven adult males (mean = 66.6 ± 4.21 mm SVL; range = 59.1-71.9) was not significantly different than that of six adult females (mean = 64.4 ± 5.92 mm SVL; range = 58.5-72.5). Ten juveniles ranged 30.7-53.5 mm SVL. A 71.3 mm SVL female captured in September contained 26 eggs with a largest follicle diameter of 3.9 mm. The smallest individual was caught in July and measured 30.7 mm SVL (Figure 10).

Additional species-Two juvenile American Toads, *Anaxyrus americanus* (Holbrook, 1836), were collected on 18 July 2008 (18.7 mm SVL) and 11 June 2009 (36.5 mm SVL). One gravid female Spring Peeper, *Pseudacris crucifer* (Wied-Neuwied, 1838) (30.4 mm SVL), was collected on 19 July 2008.

Figure 8. Monthly surface activity of two male, six female, and five juvenile Northern Redback Salamanders *(Plethodon cinereus)* at the Powdermill Nature Reserve, Rector, Westmoreland County, Pennsylvania, during May-October 2008-2009.



Discussion

As in other forested sites studied elsewhere on PNR in the early 1980s (Meshaka, 2009), the salamander guild of this study was dominated by the Allegheny Dusky Salamander to the near exclusion of other salamanders. The number of species encountered in our study was a notable departure from that of Meshaka (2009). Only four species were encountered in this study compared to the 12 (2-11) species encountered in other forested habitats by Meshaka (2009). The actual rarity of some species, such as the Longtail Salamander *(Eurycea longicauda)*, Four-toed Salamander *(Hemidactylium scutatum)*, Wehrle's Salamander *(Plethodon wehrlei)*, and Red Salamander *(Pseudotriton ruber)*, and the more strongly aquatic habits of species, such as the Northern Dusky Salamander *(Desmognathus fuscus)*, Seal Salamander *(D. monticola)*, and Spring Salamander *(Gyrinophilus porphyriticus)* best explain their absence from terrestrial sampling away from water. To that end, WEM observed an adult and a juvenile Red Salamander *(Pseudotriton ruber)* each on a different occasion prior to this study and encountered both the Northern Dusky Salamander and Spring Salamander in in White Oak Run, which passed through our study site. Only the absence of the Red-spotted Newt was surprising to us as it was encountered elsewhere on the PNR by Meshaka (2009), and, during the time of this study, elsewhere on the PNR it was both ubiquitous in ponds and encountered as a red eft on land (WEM pers. obs.).

Standardized trapping during 1981-1982 (Meshaka, 2009) and standardized collecting during 2008-2009 (this study) revealed extensive variation in monthly distributions of terrestrial captures of the Allegheny Dusky Salamander. However, for all years captures were fewest in October

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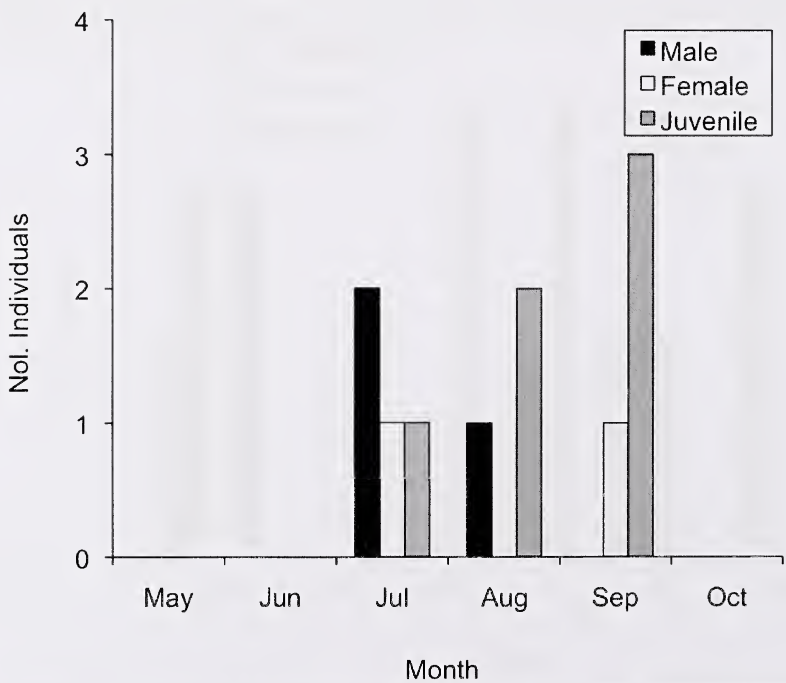
Figure 9. Monthly surface activity of three male, two female, and six juvenile Northern Slimy Salamanders *(Plethodon glutinosus)* at the Powdermill Nature Reserve, Rector, Westmoreland County, Pennsylvania, during May-October 2008-2009.

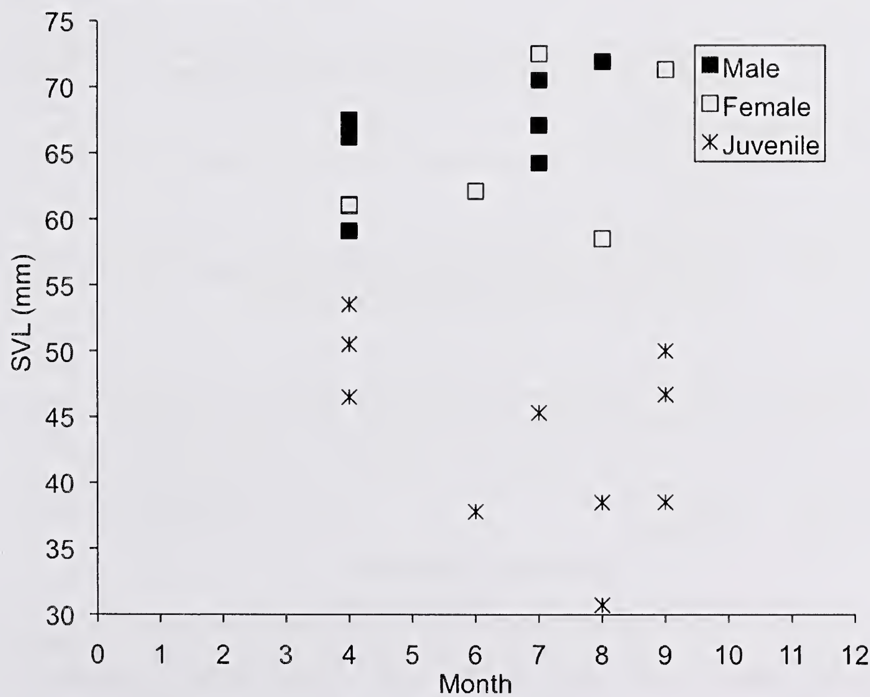


at the end of collecting surveys, and juveniles were detected during May-October. Among Redback Salamanders, seasonal terrestrial activity was bimodal in distribution with peak activity in spring and fall in both this study and that of Meshaka (2009).

The Allegheny Dusky Salamander provided the most data for intraspecific comparisons of body size and reproductive characteristics. The mean adult male body size of the Allegheny Dusky Salamander reported in our study (mean = 39.0 mm SVL) was similar to that (mean = 37.4 mm SVL) reported by Hulse et al. (2001) for Pennsylvania generally. The mean female body size reported in our study (mean = 37.7 mm SVL) was intermediate between that (mean = 35.4 mm SVL) reported by Meshaka (2009) and that (mean = 37.4 mm SVL) reported by Hulse et al. (2001) for Pennsylvania generally. Mean adult body size reported in our study differed significantly between the sexes, whereas no significant difference was found in a comparison from Pennsylvania generally (Hulse et al., 2001).

Mean clutch size of the Allegheny Dusky Salamander from our study (mean = 24.0 eggs) was larger than that (mean = 16.3 eggs) reported by Meshaka (2009), a mean value of 15.6 eggs reported by Hall (1977) from another site in Pennsylvania, and the mean value (mean = 19.1 eggs) estimated for Pennsylvania generally (Hulse et al., 2001). As in our study, a positive relationship between clutch size and female body size was detected in these aforementioned studies. The reproductive data reported for the Northern Two-lined Salamander and Northern Slimy Salamander in our study provided fecundity data unknown previously for these species on the PNR.

Figure 10. Monthly distribution of body size in seven male, six female, and 10 juvenile Northern Slimy Salamanders *(Plethodon glutinosus)* at the Powdermill Nature Reserve, Rector, Westmoreland County, Pennsylvania, during 2006-2010.



Results from this study augment those of from a study conducted in the early 1980s in primarily forested habitat elsewhere on the PNR (Meshaka, 2009). Conformity existed in species dominance between the studies, corroborated findings of greater terrestrialism in the species detected in this study and provided supplementary and novel data on reproduction for some of these species, all of which provide the sorts of ecological data necessary to make sound resource management decisions for mature forests in the northern Allegheny Mountains.

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Walter E. Meshaka, Jr. and Sarah A. Mortzfeldt, Section of Zoology and Botany, State Museum of Pennsylvania, 300 North Street, Harrisburg, PA 17120

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Seasonal Activity and Temperature Relationships of the Eastern Gartersnake, *Thamnophis sirtalis sirtalis* (Linnaeus, 1758), from an Urban Population in Erie County, Pennsylvania

Brian S. Gray

Abstract

Observations of Eastern Gartersnakes at an urban site in Erie, Pennsylvania during 2012 and 2013 revealed unimodal and bimodal activity periods, respectively. The peak of activity during 2012 occurred in July, while the bimodal peaks during 2013 occurred in May and August. Eastern Gartersnakes were observed from 31 March – 13 October, with gravid females being observed as late as 25 July. Juvenile to adult ratios significantly deviated from a 1:1 ratio during most months except March and June. Body temperatures of Eastern Gartersnakes were significantly correlated to both air ($r = 0.83$) and substrate ($r = 0.90$) temperatures. The variability in activity that occurred at the Erie, Pennsylvania site further illustrates the need for site – specific multiyear data when interpreting a species seasonal activity.

Introduction

The Eastern Gartersnake, *Thamnophis sirtalis sirtalis* (Linnaeus, 1758) (Figure 1), is one of the most abundant and frequently observed snakes in Erie County (McKinstry and Felege 1974; McKinstry and Cunningham 1980; Gray and Lethaby 2008) and in Pennsylvania in general (Hulse et al 2001; Meshaka 2009). The Eastern Gartersnake is also one of the few snakes that are able to thrive in urban landscapes in proximity to dense human populations (Hulse et al. 2001; Gibbs et al. 2007). Despite its abundance in urban settings, site-specific natural history data for the Eastern Gartersnake in Pennsylvania are sparse (Meshaka 2009; Gray 2011; Meshaka et al. 2012). Urban herpetofauna, such as Eastern Gartersnakes, have the potential to enrich the lives of urbanites with opportunities to see and interact with them (Rodda and Tyrrell 2008). While the Eastern Gartersnake may be relatively common now, there may come a time when it is not. In several areas declines have already been noted. For example, Eastern Gartersnakes declined at a former National Superfund site in Erie, Pennsylvania following the construction of a golf course (Gray 2009). At a 5 acre site in suburban Lansing, Michigan, Eastern Gartersnakes went from being seen on a daily basis (in season) in the late 1980s through the early 1990s, to scarce, with less than 10 sightings per year in the last several years (J. Harding 2014, personal communication). In Westchester County, New York declines in Eastern Gartersnakes during the 1960s and 1970s were attributed to widespread pesticide use (Gochfeld 1975). As more areas become urbanized, increasing the likelihood of population declines, the need to understand the factors that allow Eastern Gartersnakes to persist in these environments becomes more pressing. Herein, I present data regarding the seasonal activity and temperature relationships of the Eastern Gartersnake at an urban site in Erie County, Pennsylvania, in an effort to establish the baseline data needed for the development and implementation of conservation and management plans.

Materials and methods

The study site was approximately 0.5 ha of vegetated slope along the State Highway (Hwy) 832 Bridge in Erie County, Pennsylvania. The slope was dominated by Crown Vetch (*Coronilla varia*), Mugwort (*Artemisia vulgaris*), Goldenrod (*Solidago* sp.), and Late Flowering Thoroughwort

(*Eupatorium serotinum*), with a few well-separated small trees and shrubs (Boxelder, *Acer negundo*; Red-osier Dogwood, *Cornus stolonifera*; Honeysuckle, *Lonicera* sp.; and Ash, *Fraxinus* sp.) along the base. To the west of the slope, the terrain is relatively flat and consisted of ca. 3.25 ha of palustrine forest, with Eastern Cottonwood (*Populus deltoides*), Silver Maple (*Acer saccharinum*), Green Ash (*Fraxinus pennsylvanica*), and Pussy Willow (*Salix discolor*) dominating. The site, including the palustrine forest, is bounded to the north and south by residential and industrial development. The Hwy 832 Bridge creates a formidable barrier to the east. Pre-existing debris at the site included pressed wood panels, boards, shingles, linoleum, and cardboard. The herpetofauna of the site and adjacent land to the west has been reported previously (Gray 2007, 2009, and 2011).

Coinciding with a study of Dekay's Brownsnake, *Storeria dekayi* (Holbrook, 1836) during March – November of 2012 and 2013 (Gray 2014), I collected data on Eastern Gartersnakes along the Hwy 832 Bridge. Snakes were found by searching under debris or observed while moving about in the open. Search effort (2012, 2013) was as follows: March (1.4, 0.5 h), April (4.4, 4.1 h), May (6.4, 5.7 h), June (11.0, 2.2 h), July (9.8, 1.4), August (10.1, 1.5), September (6.0, 2.0 h), October (2.5, 1.4 h), and November (0.0, 0.2 h). As per Hulse et al. (2001), males that were at least 270 mm snout to vent length (SVL) and females that were at least 360 mm SVL were considered to be mature. As in many natricine snakes, sex of mature Eastern Gartersnakes was determined by examining the base of the tail. In males the hemipenes cause the sides of the base of the tail to bulge, whereas in females, the base of the tail is more tapered (Rossman et al. 1996). In male neonates and young ca. 150 mm or less, the hemipenes were manually everted by grasping the snake at mid-tail and rolling the thumb on the ventral surface towards the cloaca. It was not possible to sex all individuals. During the summer months numerous snakes fled before sex could be determined.

Figure 1. Adult female Eastern Gartersnake, *Thamnophis s. sirtalis*, found at the Hwy 832 Bridge, Erie, Pennsylvania.

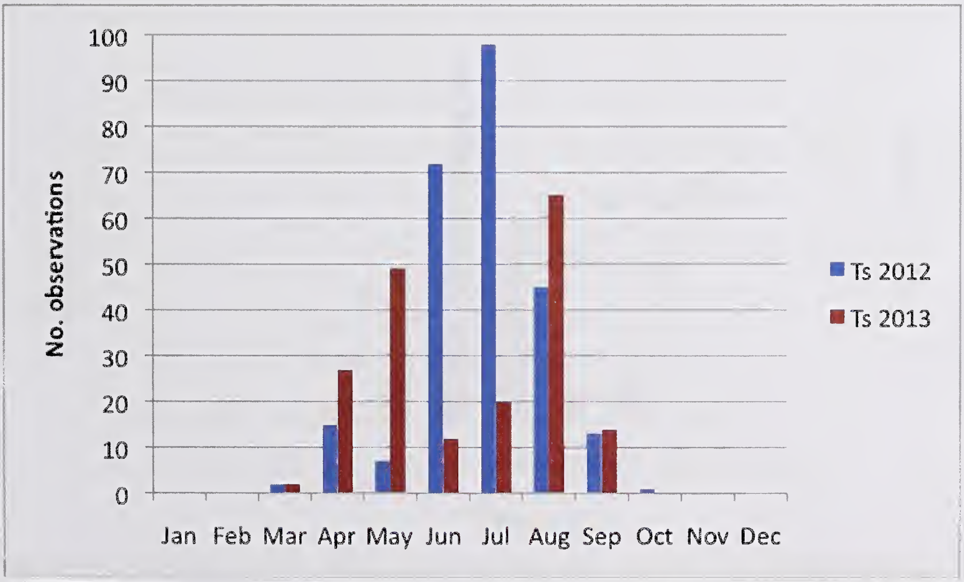
Air (AT) and substrate (ST) temperatures at the site were obtained with Lascar Electronics temperature data loggers (model EL-USB-1) with an accuracy of ± 1°C. The AT data logger was placed 1 meter above ground in a shaded area, while the ST data logger was placed 2.5 cm below the soil in a shaded area. Both data loggers were set to record every half hour. Substrate temperature data were recorded only during the 2013 season. Surface body temperature of snakes (BT) was measured with a hand-held infrared thermometer (Raytec MT-6) precise to 0.2°C (accuracy of ±1% between 10-30°C and ±1.5% outside this range). The thermometer was held approximately 200 mm from the snake and in line with the snake's body axis (Hare et al. 2007). At a distance of 200 mm, a circular area of approximately 20 mm in diameter is sampled. To lessen the likelihood of obtaining readings of both snake and substrate, only snakes that were coiled were utilized for temperature data.

Summary statistics, mean ± 95% confidence interval, range, and sample size are provided for temperature data. Chi-square (χ^2) tests employing Yate's correction for continuity (Fowler et al. 1998) were used to determine if juvenile to adult ratios deviated significantly from 1:1 ratio. I used z – tests (two tailed) to test differences between means. Linear regression and analysis of variance (ANOVA) were used to study the relationships between environmental temperatures (AT and ST) and BT. Alpha for all tests was set at 0.05. With the exception of χ^2 tests, which were calculated with the aid of a calculator, all statistical analyses were done with Microsoft Excel 2010.

Results

Eastern Gartersnakes were observed as early as 31 March, and as late as 13 October. During 2012, a unimodal activity pattern was noted, with a peak in July (Figure 2). During 2013, the activity pattern was bimodal, with peaks in May and August (Figure 2). During 2012, observations of juvenile Eastern Gartersnakes were most numerous in July (n = 80), while adults were most numerous in June (n = 27) (Figure 3). During 2013, observations of juvenile Eastern Gartersnakes were most numerous in August (n = 61), while adults were most numerous in May (n = 18) (Figure

Figure 2. Seasonal activity of Eastern Gartersnakes, *Thamnophis s. sirtalis*, during 2012 (n=253) and 2013 (n = 189) at the Hwy 832 Bridge site, Erie, Pennsylvania.



4). Gravid females were observed as late as 1 July and 25 July during 2012 and 2013, respectively. The earliest observations of neonates were 14 July and 31 July during 2012 and 2013, respectively.

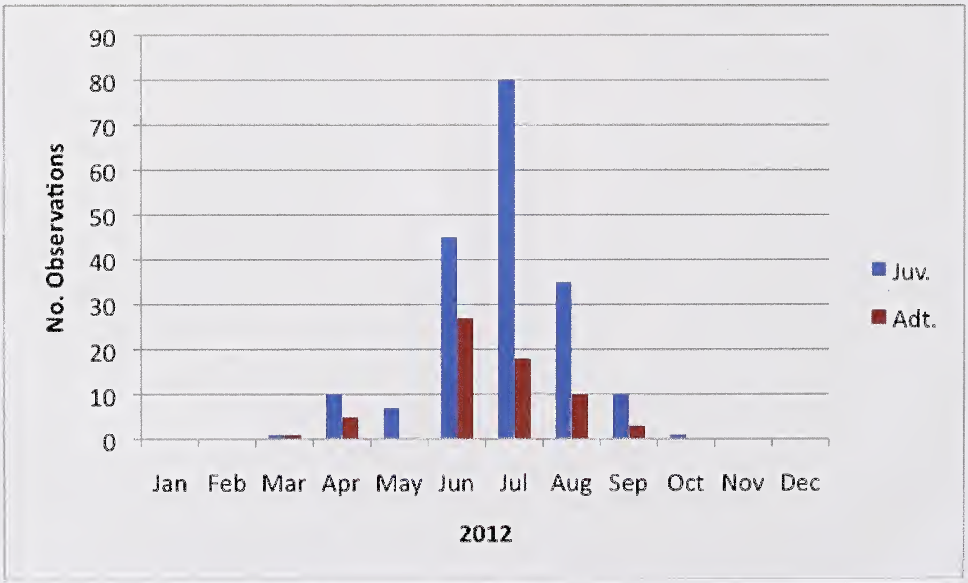
Using pooled data from 2012 and 2013, juvenile to adult ratios deviated significantly from 1:1 during April and May, and July, August, and September (Table 1). March and June did not significantly deviate from a 1:1 juvenile to adult ratio; a single observation in October precluded testing for significance for that month.

Body temperatures of Eastern Gartersnakes and environmental temperatures (AT and ST) were recorded during 107 observations during 2013. Overall BTs of Eastern Gartersnakes averaged 15.6 ± 1.4°C (range 0.2 – 30.8, n = 107). The lowest average BT (5.0°C) occurred during April; the highest average BT (24.2°C) occurred during July (Table 2). Overall ATs averaged 16.8 ± 1.2°C (range 3.0 – 28.5, n = 107). The lowest average AT (8.0°C) occurred during March; the highest average AT (22.1°C) occurred during July (Table 2). Overall STs averaged 15.7 ± 1.2°C (range 4.9 – 26.5, n = 107). The lowest average ST (5.0°C) occurred during March; the highest average ST (21.0°C) occurred during July (Table 2). There was no significant difference (z = -1.31, P = 0.19) between BT and AT. A positive correlation existed between snake BTs and ATs (r = 0.83) (Figure 5), and this correlation was significant (ANOVA F = 240.20, df = 1, 105, P<0.001). Likewise, there was no significant difference (z = -0.05, P = 0.96) between BTs and STs. A positive correlation existed between snake BTs and STs (r = 0.90) (Figure 6), and this correlation was significant (ANOVA F = 459.43, df = 1, 105, P<0.001).

Discussion

The relative abundance of the Eastern Gartersnake at the Hwy 832 Bridge site was similar to other sites in Erie County (McKinstry and Felege 1974; McKinstry and Cunningham 1980; Gray 2006, 2011) and elsewhere in Pennsylvania (Meshaka 2010; Meshaka et al. 2012), where it is one of the most frequently observed snake species. At the Hwy 832 Bridge site it is second only to Dekay's

Figure 3. Seasonal activity of juvenile (n = 189) and adult (n = 64) Eastern Gartersnakes, *Thamnophis s. sirtalis*, during 2012 at the Hwy 832 Bridge site, Erie, Pennsylvania.



Brownsnake (Figure 7), which is frequently found in aggregations with Eastern Gartersnakes (Gray 2013). Eastern Gartersnakes were also the most abundant snake observed in a snake assemblage in nearby Ohio (Meshaka et al. 2008).

Several natural history traits have been associated with amphibians and reptiles that fare well in urban environments (Rodda and Tyrrell 2008), and many of these are displayed in the East-

Figure 4. Seasonal activity of juvenile (n = 143) and adult (n = 46) Eastern Gartersnakes, *Thamnophis s. sirtalis*, during 2013 at the Hwy 832 Bridge site, Erie, Pennsylvania.

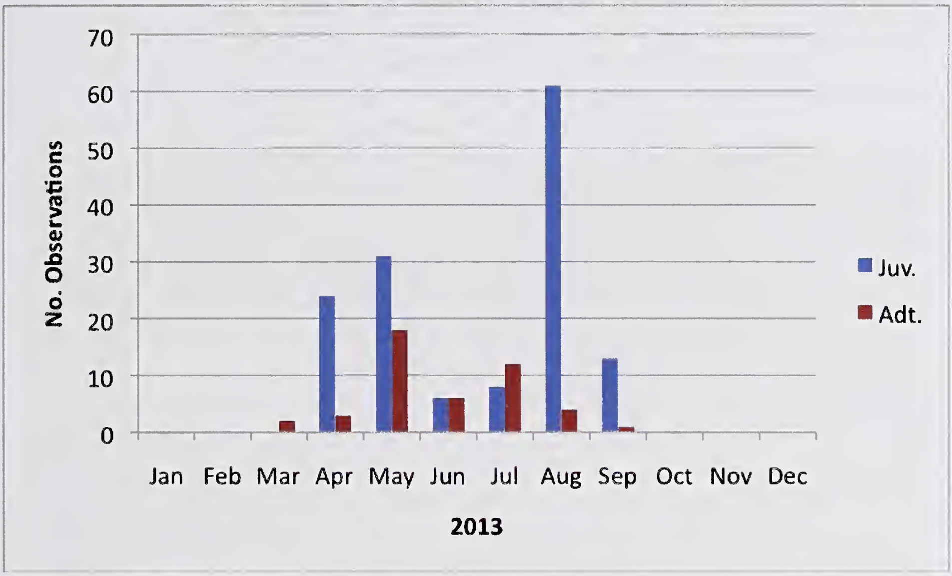
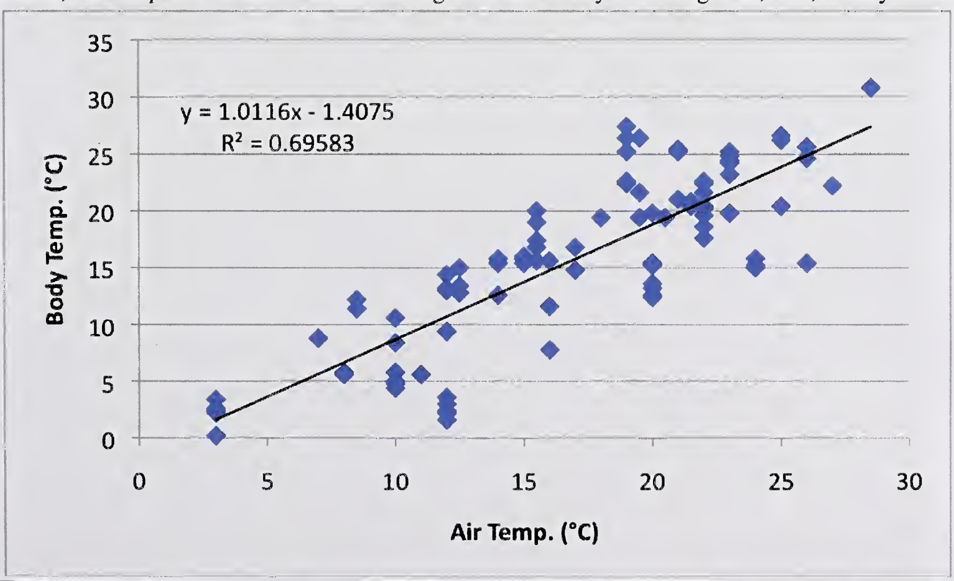


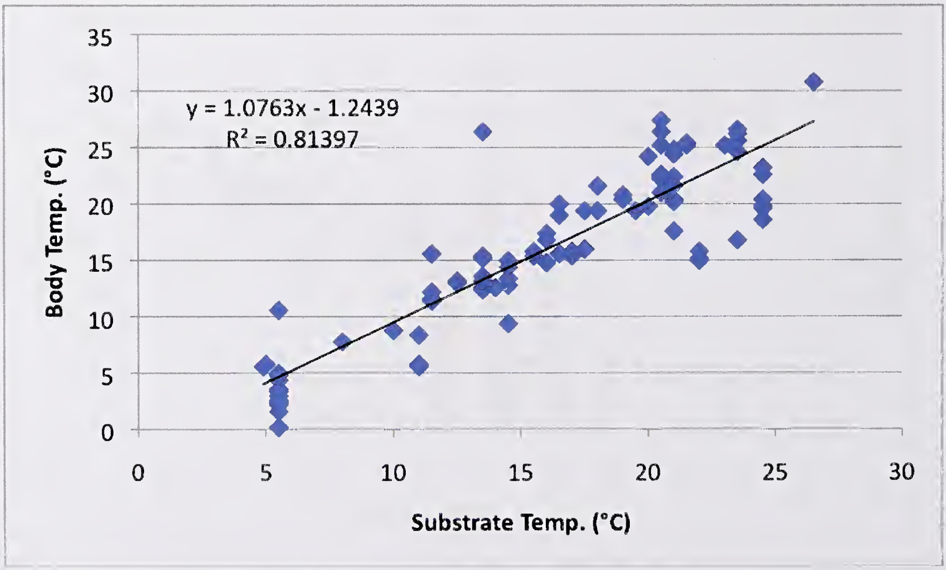
Figure 5. Relationship between air temperatures and body temperatures (n =107) of Eastern Gartersnakes, *Thamnophis s. sirtalis* observed during 2013 at the Hwy 832 Bridge site, Erie, Pennsylvania.



ern Gartersnake. For instance, the Eastern Gartersnake tolerates a broad range of habitats. In the Northeast this species may be found in virtually any habitat, from open talus slides and cultivated fields to closed – canopy deciduous and coniferous forests and from swamps, marshes, and bogs to dry upland habitats (Hulse et al. 2001). Eastern Gartersnakes are generalist predators, taking a wide variety of prey, such as earthworms, anurans, salamanders, snakes, birds, small mammals, and even carrion (Ernst and Ernst 2003; Gray 2002, 2012). Several of these prey types (e. g., earthworms, anurans, and salamanders) are relatively common and are consumed by Eastern Gartersnakes at the Hwy 832 Bridge site. Female Eastern Gartersnakes are quite fecund, producing up to 30 young in Pennsylvania (Hulse et al. 2001), and up to 85 have been reported elsewhere (Fitch 1985). In addition, Eastern Gartersnakes are rather sedentary (Hulse et al. 2001) and have small home ranges, which may lessen the likelihood of encounters with urban predators (e. g., cats and dogs) and automobiles (Rodda and Tyrrell 2008). No Eastern Gartersnakes were found dead on roads (DOR) in the vicinity of the Hwy 832 Bridge site. In contrast, Dekay's Brownsnakes were found DOR on 5 occasions during 2012 (Gray 2014) and a single occasion during 2013. Most movements of *T. sirtalis* in a Michigan population were less than 183 m, and home range was estimated to be approximately 0.8 ha (Carpenter 1952). Freedman and Catling (1979) also reported relatively short movements of 153 m or less. Abundant earthworm prey along the Hwy 832 Bridge and relatively abundant amphibian prey (e. g., American Toad, *Anaxyrus americanus*; Green Frog, *Lithobates clamitans*; Spring Peeper, *Pseudacris crucifer*; Spotted Salamander, *Ambystoma maculatum*) in the adjacent swamp forest make long-distance peregrinations for food unnecessary. At other sites greater distances may need to be travelled if feeding areas and hibernacula are widely separated (Ernst and Barbour 1989).

Eastern Gartersnakes may be active in every month in Pennsylvania (Hulse et al. 2001). The earliest and latest dates of observation at the Hwy 832 Bridge site were within the range of 9 March and 1 December reported previously for Erie County Eastern Gartersnakes (Gray and Lethaby 2008, 2012). With pooled data from two Erie County sites, Gray (2011) reported a unimodal activity

Figure 6. Relationship between substrate temperatures (n = 107) and body temperatures (n =107) of Eastern Gartersnakes, *Thamnophis s. sirtalis* observed during 2013 at the Hwy 832 Bridge site, Erie, Pennsylvania.



pattern with a peak in June. McKinstry (1975) provided data for Eastern Gartersnakes at Presque Isle State Park during July – November, with most (45%) observations occurring in October. This is in contrast to the current study, which had very few observations during October. Interspecific differences in activity periods of Eastern Gartersnakes and Dekay's Brownsnakes were evident at the Hwy 832 Bridge site. While Eastern Gartersnakes displayed a unimodal peak in 2012 and a bimodal peak in 2013, Dekay's Brownsnake displayed bimodal activity periods both years (Gray 2014, unpublished data). Year to year differences in climate could have partly been the cause of some of this variability. For example, an unseasonably hot and dry summer during 2012 contributed to a decrease in activity of Dekay's Brownsnakes at the Hwy 832 Bridge site (Gray 2014). This decrease was likely in response to prey scarcity (i. e., slugs) on the slope of the bridge. The increased

Figure 7. Dekay's Brownsnake, *Storeria dekayi* (arrow) found with two Eastern Gartersnakes beneath shingle debris at the Hwy 832 Bridge site, Erie, Pennsylvania.

average temperatures possibly affected Eastern Gartersnakes in another way. The unseasonably hot weather during 2012 may have allowed for earlier parturition; neonate Eastern Gartersnakes were observed 17 days earlier in 2012 than during 2013. In Dekay's Brownsnake at the Hwy 832 Bridge site, the bimodal peaks in activity were approximately a month earlier (April and July) during 2012 than during 2013 (May and August).

Although a unimodal activity pattern is typical of Eastern Gartersnakes in Erie County (McKinstry 1975; Gray 2011) and Pennsylvania in general (Hulse et al. 2001; Meshaka 2010), bimodal activity has been noted for a south-central Pennsylvania population (Meshaka et al. 2008). However, to my knowledge, the present study is the first report of both patterns occurring during successive years at a single Pennsylvania site.

The high number of juveniles observed in July (2012) and August (2013) coincided with the latest dates gravid females were seen (1 and 25 July), and the first sightings of neonates (14 and 31 July). During July 2012, nearly 82% (80 of 98) of observations were of juvenile Eastern Gartersnakes. This suggests that adult females may have dispersed after parturition into the adjacent swamp forest and open areas, potentially to feed on anurans, while juveniles remained at the debris piles on the slope to feed on earthworms. The relative abundance of juveniles compared to adults during most months in this study is in contrast to other sites in Pennsylvania (Meshaka 2009, 2010; Meshaka et al. 2012), where adults greatly out-number juveniles. It is likely that adults are using habitats not used by juveniles in and adjacent to the swamp forest, which was not sampled during this study.

Like other ectothermic squamates, environmental temperatures influence practically every aspect of the ecology of the Eastern Gartersnake. Substrate temperature was a better predictor of snake BT than AT was. This is unsurprising as 105 of the 107 (98.1%) snakes used in the BT analysis at the Hwy 832 site were found under cover. These snakes likely retreated under cover the night before, and remained there until observed the following morning. While under the debris they would inevitably conform to the ST, which maintained a narrower range of temperatures than did AT. Since most observations of Eastern Gartersnakes were in the morning and under debris, the BTs in this study most likely represent temperatures passively experienced by the snakes, and not necessarily temperatures chosen by them.

Approximately half of the cloacal temperature readings of active Michigan Eastern Gartersnakes were between 25 and 30°C (mean = 25.6°C) (Carpenter 1956). Mean cloacal temperature of Eastern Gartersnakes during March - July in Ohio was 26.1°C (Dalrymple and Reichenbach 1981).

Table 1. Monthly ratios of juveniles (n = 332) to adults (n = 110) during 2012 and 2013 at a site in Erie, Pennsylvania. Degrees of freedom (df) for all comparisons was 1. Statistical significant results are indicated by an asterisk.

Month	Juveniles	Adults	$\chi2$	P
March	1	3	2.25	n. s.
April	34	8	14.88	< 0.01*
May	38	18	6.45	< 0.05*
June	51	33	3.44	n. s.
July	88	30	27.53	< 0.01*
August	96	14	59.64	< 0.01*
September	23	4	12	< 0.01*
October	1	0	N/A	N/A

Aleksiuk (1976) noted that the majority of Red-sided Gartersnakes, *T. s. parietalis* are active at BTs of 18 – 30°C, and seek shelter when BT falls below 17°C. The BTs of Eastern Gartersnakes at the Hwy 832 Bridge site are consistent with those of Aleksiuk's. The two Eastern Gartersnakes found basking were observed 31 March and 16 May 2013, and had BTs of 5.6°C and 26.4°C, respectively. The low BT of the first individual was due to the snake recently emerging and just beginning to bask.

Gibbons and Semlitsch (1987) pointed out that seasonal activity can be valuable in identifying general trends and generating hypotheses as to why a particular pattern has evolved and is maintained. There is inter- and intraspecific geographic variation among activity patterns and reproductive seasons in Eastern Gartersnake populations. This variation underscores the need for regional and site-specific natural history data for predictive power in hypothesis testing, and in forming management plans (Meshaka et al. 2008; Meshaka 2010). The seasonal activity data reported in the present paper not only add to our baseline knowledge of the Eastern Gartersnake in northwestern Pennsylvania, but also emphasizes the variability that may occur within and between sites over time. As more site-specific data are acquired for the Eastern Gartersnake and other snake species in Pennsylvania, it would be of great interest to compare inter- and intraspecific differences in seasonal activity and other natural history traits between urban and more rural sites. Identifying key differences might shed light on what allows a particular species to persist in urban areas, and also to identify if there are thresholds that, if crossed would lead to declines even in these urbanophiles.

Table 2. Summary of body temperatures (BTs) of Eastern Gartersnakes, air temperatures (ATs), and substrate temperatures (STs) at a site in Erie, Pennsylvania.

Month	BTs (°C)	ATs (°C)	STs (°C)
March	5.7 ± 1.3	8.0 ± 0.0	5.0 ± 0.6
	5.6 - 5.8 (n = 2)	8.0 (n = 2)	4.9 - 5.0 (n = 2)
April	5.0 ± 1.6	9.3 ± 2.0	6.6 ± 1.0
	0.2 - 15.6 (n = 22)	3.0 - 16.0 (n = 22)	5.5 - 11.5 (n = 22)
May	18.0 ± 1.5	20.0 ± 1.3	18.6 ± 1.5
	5.8 - 27.4 (n = 41)	10.0 - 26.0 (n = 41)	11.0 - 24.5 (n = 41)
June	17.4 ± 7.0	19.5 ± 8.9	17.6 ± 5.0
	12.6 - 22.2 (n = 4)	14.0 - 27.0 (n = 4)	14.0 - 20.5 (n = 4)
July	24.2 ± 4.6	22.1 ± 3.9	21.0 ± 3.1
	19.4 - 30.8 (n = 6)	18.0 - 28.5 (n = 6)	17.5 - 26.5 (n = 6)
August	21.1 ± 1.6	19.6 ± 1.4	19.1 ± 1.1
	15.6 - 26.6 (n = 22)	15.5 - 25.0 (n = 22)	16.0 - 23.5 (n = 22)
September	13.6 ± 1.5	12.4 ± 1.7	14.4 ± 1.3
	9.4 - 16.0 (n = 10)	8.5 - 15.0 (n = 10)	11.5 - 17.5 (n = 10)

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Brian S. Gray. Natural History Museum at the Tom Ridge Environmental Center, 301 Peninsula Drive, Erie, Pennsylvania 16505, brachystoma@hotmail.com

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The Red-eared Slider, *Trachemys scripta elegans* (Wied, 1838), Established in Pennsylvania

Abstract.

Several aspects of the ecology of the Red-eared Slider, *Trachemys scripta elegans,* was examined from a collection made during 2012-2013 from a population inhabiting a canal in south-central Pennsylvania. Sexual maturity was reached by both sexes at an early age and small body size. Typical of the species, adult body sizes of males were smaller than those of adult females. Like those of other northern populations, females at our site produced potentially large clutches generally twice each year. Body size distribution of our sample was indicative of a growing population. A successful colonizing species, extralimitally both in the United States and on other continents, we are not surprised by its establishment in Pennsylvania. However, in light of its popularity in the pet trade and its demonstrable success at both our site and elsewhere in the mid-Atlantic and northeastern regions, we proffer that if ignored the Red-eared Slider has a strong likelihood of becoming a geographically widespread species in Pennsylvania.

Introduction

The Red-eared Slider, *Trachemys scripta elegans* (Wied, 1838), is an aquatic turtle of primarily lentic systems of the central portion of the United States (Ernst et al., 1994; Conant and Collins, 1998). Although this species, popular in the pet trade, has been reported extralimitally in the United States, established populations are less frequently documented in the literature (Conant and Collins, 1998; Somma et al., 2013). Established populations of the Red-eared Slider have not previously been reported for Pennsylvania, but nearby the species occurs naturally in southwestern West Virginia (Conant and Collins, 1998) and as an exotic in eastern Maryland (Harris, 1975), Delaware (White and White, 2002), and southeastern Virginia (Mitchell, 1994). Using the criteria of Meshaka et al. (2004) and Meshaka (2011) associated with colonization- a voucher, evidence of breeding, and presence for at least one generation- we examined a series of specimens of the Red-eared Slider removed from a canal in a county park in south-central Pennsylvania to determine the status of the species.

Materials and Methods

The mark-recapture study of aquatic turtles was conducted at Wildwood Park in Harrisburg, PA (40° 18' 32.03", -76° 53' 10.76") (Figure 1a). The study area was a segment of the old Pennsylvania Canal system (Figure 1b). The canal was historically used for the transportation of cargo, however it has not been used for this function since the early 1900s. The canal segment measured 1,935 m in length with a mean of 13 m in width and an estimated 2.5 m in depth. The total area of the canal was 26,467 square meters. The east side of the canal was bordered by the original "Tow Path". Distance from the tow path to the edge of the canal varied from one to two meters and was very steep. The tow path was lined with Pin Oak *(Quercus palustris)*, Persimmon *(Diospyros virginiana)* Black Ash *(Fraxinus nigra)* (few), Box Elder *(Acer negundo)*, Silver Maple *(Acer saccharinum)*, and Black Locust *(Robinia pseudoacacia)* (few). The understory consisted of Jetbead *(Rhodotypos scandens)*, Tartarian Honeysuckle *(Lonicera tatarica)*, Japanese Honeysuckle *(Lonicera japonica)*, Blackberry *(Rubus sp.)* and Greenbrier *(Smilax sp.)* The emergent plants in the riparian zone were Swamp Rose Mallow *(Hibiscus moscheutos)*, Yellow Iris *(Iris pseudocoris)*, some sedges, Buttonbush *(Cephalanthus occidentalis)* and Small Beggar's Tick *(Bidens discoidea)*. The Small Beggar's Tick generally grew epiphytically on Buttonbush or floating logs in the canal. The dominant water lily was Spadderdock *(Nuphar sp.)*. There are also algae species in the water which

Figure 1. (A) View of the wetland at Wildwood Park, in Harrisburg, Dauphin County, Pennsylvania, on 11 March 2014. Note the shallowness of the wetland and the encroaching woody-stemmed vegetation. The treeline on the left borders the canal. Photograph by EW. (B) The canal habitat of a Red-eared Slider *(Trachemys scripta elegans)* population in November 2013. The wetland is located on the other side of the treeline. Photograph by EW.

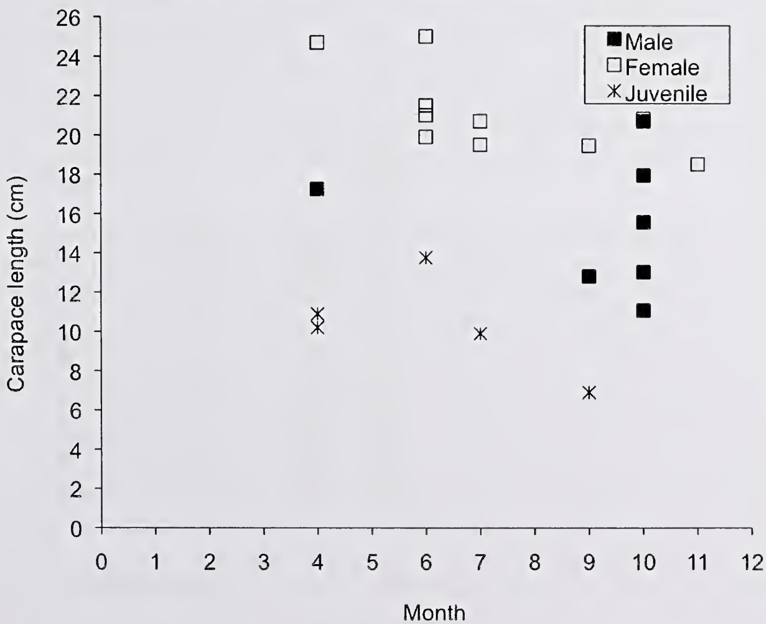
were not identified. A spillway from Paxton Creek to Wildwood Park is situated along the eastern border of the tow path. The West side of the canal is a utility right-of-way with trees cleared from the tract. This area varied 4.5-34.3 m in width and was bordered by Industrial Drive, a road lined on its west side by shipping warehouses. This area is dominated by perennial sun-loving plants. Oriental Bittersweet *(Celastrus orbiculatis)* Poison Ivy *(Toxicodendron radicans)*, Staghorn Sumac *(Rhus typhina)* Goldenrod *(Solidago sp)* and an annual species, Sweet Annie *(Artemisia annua).*

In conjunction with a long-term mark-recapture project of aquatic turtles begun in Spring 2011, Red-eared Sliders *(Trachemys scripta elegans)* were captured in baited hoop nets that were set during April-November in both 2012 and 2013. A total of 25 trap days with 220 traps. Five of the eight traps used had 1 m openings with 2.5 cm mesh (Code: TN310), two of the traps had 45.7 cm openings with 3.8 cm mesh (Code: TN215), and the last trap had a 1 m opening with 3.8 cm mesh (Code: TN315)(Fig. 1). All traps were purchased from Memphis Net & Twine Co. Red-eared Sliders were euthanized, fixed in formalin, and later preserved in 70% methylated alcohol. All specimens were deposited in the section of Zoology and Botany of the State Museum of Pennsylvania. All statistics were calculated using Excel. Means are followed by ±1 standard deviation (SD). Statistical significance was recognized at 0.05 level.

Results

During 2012-2013, 22 Red-eared Sliders were captured and removed from the canal at Wildwood. Individuals were captured in each month of trapping (Figure 2). During this same period, 138 new captures of the Painted Turtle *(Chrysemys picta)* and 19 new captures of the Common Snapping Turtle *(Chelydra serpentina serpentina).*

Figure 2. Monthly distribution of body sizes of males (n= 7), females (n= 10), and juveniles (n= 5) of the Red-eared Slider *(Trachemys scripta elegans)* captured during April 2012-October 2013 at Wildwood Park in Harrisburg, Dauphin County, Pennsylvania.



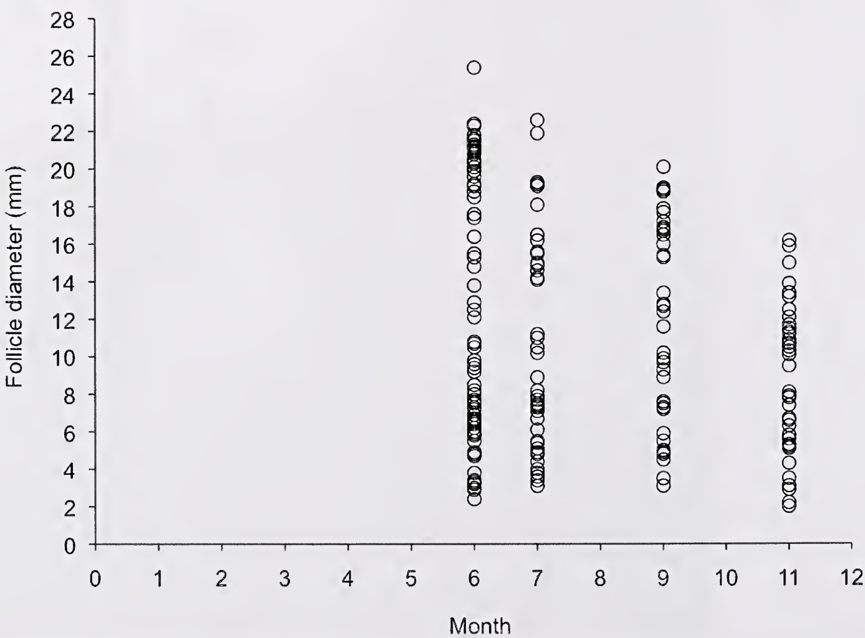
Among the adult Red-eared Sliders, mean body sizes of seven males (mean = 15.5 ±3.4 cm CL; range = 11.1-20.7) and females (mean = 21.1 + 2.2 cm CL; range = 18.5-25.0) differed significantly (two-tailed t = 2.131; df = 15; p = 0.0008) from one another. The adult male: female sex ratio of 0.41:1.00 was not significantly differ from unity (X2 = 0.5294; p > 0.05).

Five juveniles ranged 6.9-13.8 cm CL and represented 22.7% of a growing population. The smallest juvenile (6.9 cm CL) was captured in September 2013 and had one discernible plastral ring. The smallest sexually mature males had two (11.1 cm CL) or three (13.0 cm CL) plastral rings. The smallest sexually mature females had five (20.7 cm CL) or six (18.5, 19.5, 20.8 cm CL) plastral rings.

Enlarged follicles were evident in all females captured during June-November, with the largest ovarian follicles having progressively diminished in size after June (Figure 3). A 21.5 cm CL captured on 21 June 2012 contained four shelled eggs, the length and width from which could be measured from three of the eggs (mean = 37.4 ± 0.8 mm; range = 36.5-38.0 X mean = 23.6 ±0.7 mm; range = 23.1-24.4). Four luteal scars of at least 9 mm were present indicating a complete clutch. The yolk from the damaged shelled egg measured 27.2 mm. Eight ovarian follicles approaching ovulatory size (18.5-25.4 mm) were present in this female as a potential second clutch for the season. The largest groups of similarly-sized follicles ranging approximately 5-7 mm from each female provided a mean clutch size estimate of 9.2 eggs (SD = 5.8; range = 3-19; n = 7).

Multiple clutch production was evident in this population. A single set of luteal scars was present in each of two of the three females collected in June, in one of two females collected in July, and in the female collected in November. These females each contained a distinct set of enlarged follicles, indicating potential of a second clutch for the season. The two June and July females in

Figure 3. Monthly distribution of 207 follicle diameters of at least 2.0 mm in females (n= 7) of the Red-eared Slider *(Trachemys scripta elegans)* captured during April 2012-October 2013 at Wildwood Park in Harrisburg, Dauphin County, Pennsylvania.



which corpora lutea were not present were also found to have had two distinct sets of enlarged follicles, thereby suggesting the potential of two clutches for the season. The female captured on 2 September was found to contain two sets of luteal scars and 15 ovarian follicles ranging 15.3-20.1 mm, indicating that at least two clutches had been laid and a third clutch was near ovulation before the end of the season. Thus, production of two clutches annually with an average reproductive potential of 18.4 eggs per year was the rule for this sample; however, production of three clutches annually by some portion of the population could not be ruled out.

Discussion

Individual Red-eared Sliders have been seen in the canal since at least 2002, and in the past 12 years individuals have occasionally been captured and removed from the canal. Those observations and removals corroborate the assertion that the Red-eared Slider has long had an appearance in the canal. Communications by park staff of having to dissuade visitors who wished to release unwanted adult-sized Red-eared Sliders into the park point to the likeliest source of its introduction and ongoing contribution to the adult population. Based upon our findings of mixed size-classes, the smallest of which were smaller (2.0-3.5 cm CL; Cagle, 1950) than the 2.5 cm mesh size of the hoop traps, evidence of reproduction, and persistence for at least one generation, meet criteria associated with an established colony (Meshaka et al., 2004; Meshaka, 2011). Repeated introductions of unwanted adults can provide a buffer to this population; however, in light of being a self-sustaining and growing population, released pets could represent excess if at some point the canal population were to reach carrying capacity.

Although our life history data from this population are few, some comparisons are possible. Mean body sizes of adults and the extent of body-size dimorphism of our site fell within the range recorded elsewhere for males and females, respectively: 18.4 and 20.8 cm CL in Indiana (Minton, 2001), 14.8 and 23.7 cm CL from a canal in Miami, Florida (Meshaka, 2011), 16.7 and 22.0 cm CL from a pond in Miami, Florida (Witzell, 1999).

Age at sexual maturity at our site for males (2-3 years) and females (5-6 years) likewise fell within the range recorded elsewhere: 3-4 years for turtles in Indiana (Minton, 2001), three years in females from artificially heated pond and four years in a control pond in southeastern Illinois (Thornhill, 1982), three years in males and four years in females from Oklahoma (Webb, 1961), 3-5 years in males depending on habitat quality and approximately eight years in females regardless of habitat quality in South Carolina (Gibbons et al., 1981), 2-5 years for turtles in southern Louisiana (Cagle, 1950).

The Red-eared Slider is a fecund species. Mean and maximum clutch sizes can be large. Three clutches are often produced annually, and the subsequent estimated reproductive potential, or total number of eggs produced annually, can be large. For example at our site, females averaged nine eggs per clutch and up to 19 eggs per clutch. Eggs were laid generally twice, but potentially three times each year, with a conservative average reproductive potential of 18.4 eggs produced annually. In southeastern Illinois, mean clutch size was similar between a heated (12.5 eggs) and a control (11.1 eggs) pond (Thornhill, 1982). From 2.6 and 2.9 clutches produced per year in a heated and control pond, respectively, estimated reproductive potential was significantly larger in females of the heated pond (36.50 eggs/year) than in those of the control pond (27.95 eggs/year) (Thornhill, 1982). Evidence existed for four clutches in one female from each of Thornhill's (1982) study ponds. In Lake Texoma, Oklahoma, 1-12 eggs were produced 2-3 times each year (Webb, 1961), and in Arkansas, an average of 11 eggs (range = 8-17) were produced 2-3 times annually (Trauth et al., 2004). Clutch size of the Red-eared Slider could be up to 22 eggs in Kansas (Collins et al., 2010), clutch size averaged seven eggs (range = 2-19) in southern Louisiana (Cagle, 1950),

and 9-12 eggs could be produced in a clutch in Miami, Florida (Meshaka, 2011). A 21 cm CL female Red-eared Slider captured on 18 July 2013 from a pond in Westmoreland County, Pennsylvania, showed evidence of having laid a clutch of six eggs the potential for a future clutch of 6-14 eggs (Russell et al., 2014).

We do not know the egglaying season at our site; however, follicles nearing ovulation were apparent from at least 21 June and also on 16 July. Clutches were laid in three-week intervals in southeastern Illinois (Thornhill, 1982), sufficient for the nesting seasons of the heated (mid-May-late-June) and control (23 May-mid-July) pond. A three-week interval between clutches was indicated for Thornhill's (1982) study and would accommodate two clutches during a conservatively estimated nesting period of two months at our site.

Results of our study confirm an established population of the Red-eared Slider in a segment of what was once the Pennsylvania Canal system in a county park in south-central Pennsylvania. Preliminary results of selected life history traits examined in these individuals corroborated our assessment that turtles of this population mature at a young age and are highly fecund, two traits often found in other populations of this species and in successful colonizing species generally (Baker, 1965; Ehrlich, 1989). This species can also be very long-lived, up to 50-75 years (Cagle, 1950). If high life expectancy is a life history trait associated with this population, the colonizing advantage of high fecundity (multiple clutch production each year over many decades) would hinder eradication efforts even more so if females are also wary. For Wildwood specifically, Red-eared Sliders will continue to be removed and we advocate the implementation of signs that prohibit release of this or any species in the park as well as information regarding this species. For Pennsylvania generally, we use our results from Wildwood Park to spur interest in assessing the status of this species across the state as well as to warrant reconsideration of the rules associated with its ownership in the state.

Acknowledgments

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[1,2]Julia L. Russell, [3]Eugene Wingert, [3]Scott M. Boback, and [2]Walter E. Meshaka, Jr.

[1]Department of Biology, Shippensburg University, 1871 Old Main Drive, Shippensburg, Pennsylvania 17257 USA

[2]Section of Zoology and Botany, State Museum of Pennsylvania, 300 North Street, Harrisburg, Pennsylvania 17120 USA

[3]Department of Biology, Dickinson College, Post Office Box 1773, Carlisle, Pennsylvania 17013 USA

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First Records For The States Of San Luis Potosí And Querétaro, Mexico Of Rusty-Headed Snake *Amastridium Veliferum* (Serpentes: Colubridae)

During fieldwork in Las Pozas, Xilitla, San Luis PotosÍ (21.394333° N, 98.994639° W; WGS84) we found a young *Amastridium veliferum* (Rusty-headed Snake) on a stone trail on 13 October 2013, a picture of this individual was verified by Julio Lemos Espinal. Photos of this specimen were deposited in collection of the Museo de las Ciencias Biológicas "Enrique Beltrán," FES-Iztacala, UNAM (MCBFESIR-282) (Figure 1).

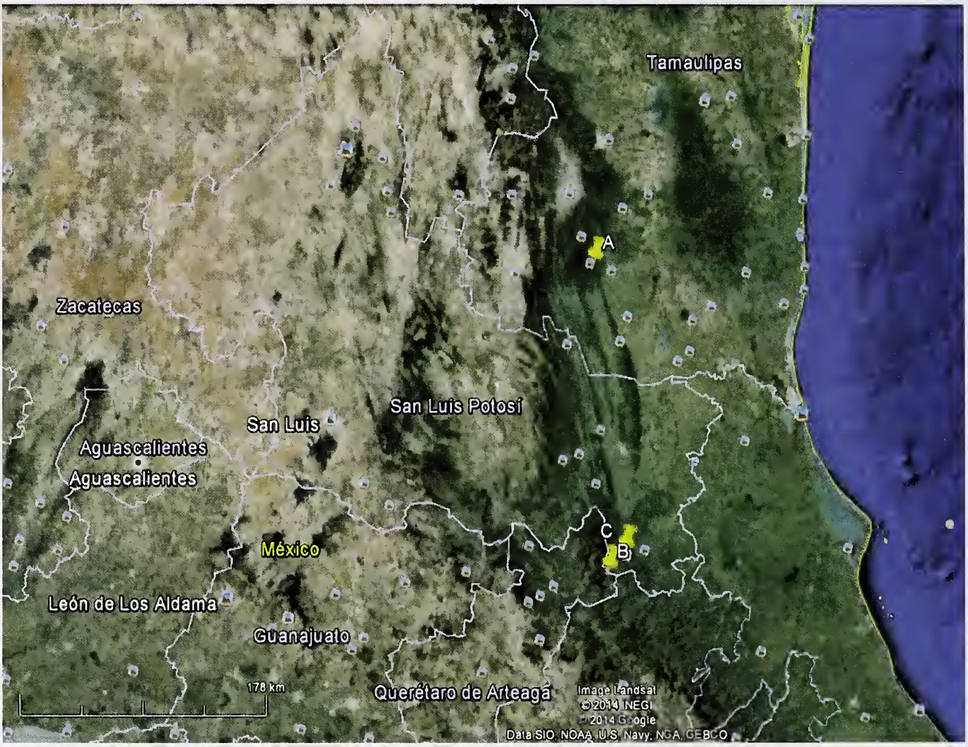
We also found an unpublished record from the state of Querétaro from Cornell University Museum of Vertebrates (CUMV Reptiles 10386) from 2.8 mi. W El Madroño, Querétaro or 11.9 mi. W Xilitla San Luis Potosí, on 29 July 1973, this individual was identified by Alan H. Savitzky (Figure 2).

Both records are about 184 km south of the nearest locality at Rancho El Cielo 7 km northwest of Gómez Farías, Tamaulipas (Martin, 1955) These records contribute to a more accurate understanding of the distribution of this species (Figure 3). These records represent the first records of this species in Querétaro and San Luis Potosí.

Figure 1. *Amastridium veliferum* from Las Pozas, Xilitla, San Luis Potosí.

Figure 2. Specimen of *Amastridium veliferum* reported here from west of El Madroño Querétaro or 11.9 mi. west of Xilitla San Luis Potosí.

Figure 3. Range extension of *A. veliferum* (184 km south of the nearest record in El Cielo, Tamaulipas (location A). The two new localities reported here are B and C.



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Rafael Alejandro Calzada-Arciniega and César Toscano Flores, Laboratorio de Herpetología, Facultad de Estudios Superiores Izatacala, Universidad Nacional Autónoma de México, Tlalnepantla, Estado de México 54090, México (e-mail: ralejandrocalzada89@gmail.com)

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An Isolating Mechanism, Between the Cryptic Species *Hyla chrysoscelis* Cope and *Hyla versicolor* Le Conte in a Sympatric Population, other than Voice

Nobel and Hassler (1936) first published that there were two distinct mating calls, in what was recognized as *Hyla versicolor.* Subsequent authors Blair (1958), Johnson (1959, 1963), Littlejohn et al. (1960) demonstrated evidence that two species were present and methods for separating their calls. Blair (1958), Johnson (1966), and Ralin (1968) published maps refining their distribution . Zweifel (1970) extended the known distribution of *Hyla chrysoscelis* to northern Virginia, Delaware and New Jersey and reported a case of sympatry in Delaware. He also reported on the difference temperature plays in the calls of *H. chrysoscelis* and *H. versicolor*.

I generally tell colleagues that if you can hear and count "bumps" in the call it is a *versicolor* and that if the trill was very fast and you could not discern those "bumps", enough to count them, it was *H. chrysoscelis*. I have, what I presume, is "normal hearing". If one has exceptional hearing perhaps they could hear "bumps" somewhat in *H. chrysoscelis* calls. I noticed no difference in the calls of either species at different temperatures (48 to 80 degrees F.).

The purpose of this note is to report on a sympatric population of these two species in Severn, Maryland. The pond is elongated (reported area of roughly 34,214 sq. ft., Kathleen Chow) and runs NE to SW and is a storm water pond (a settling pond when I first started working here in the mid eighties) in a well- developed area and is located within the manicured lawns of an Anne Arundel County school. I first became interested in the *H. chrysoscelis* this year when I noticed they started calling earlier in the year than *H. versicolor* and were calling while it was daylight. *H. chrysoscelis* arrived at the pond after a heavy rain (1.0") on 15-16 April 2014 at a temperature of 36(9:05 PM)/42(9:05 PM) degrees F. After many trips to the pond during the day and early morning, I discovered they actually started calling around 5:00 AM (25 May, 31 May 2014) at the first sign that daylight was iminent. I then wondered when they stopped calling and discovered it was just prior to when it became dark at 9:00 PM (9-11 June 2014). Amazingly, *H. chrysoscelis* literally was calling with the birds.

I was only able to define when they stopped calling when *H. versicolor* was not calling. When *Hyla chrysoscellis* is calling, it is normally 1 to 6 individuals and you can wait minutes between calls. Rain does not seem to affect them in any way as I noticed no difference in their calling. A good rain in the afternoon, however, does seem to allow them to call later at dusk.

Hyla versicolor arrived at this pond after a heavy rain (1.54") on 30 April-1 May 2014 at a temperature of 63(8:05PM)/66(8:05PM) degrees F. *Hyla versicolor* usually started calling while still daylight but just before it started to get dark and in chorus drowns out any *H. chrysoscelis* calling. An interesting observation was that when *H. versicolor* started calling and *H. chrysoscelis* was already calling some males appeared to try and mimic the *H. chrysoscelis* calls. Some were so good it was challenging to be sure who was calling. Is it possible that these males represent hybrids?

In this pond there appears to be a separation in breeding stations between the species. *H. chrysoscelis* breeds on the NW side in the tall sedges, a very confined space, whereas *H. versicolor* breeds mainly on the opposite side of the pond. Both species are protracted breeders. *Hyla versicolor* seemed to finish breeding toward the end of May, after which individuals still called from the adjacent trees. *H. chrysoscelis* is still calling from the rushes in which it started calling.

Figure.1. Habitat of *Hyla chyrsoscelis*. (Sedges tentatively identified as *Carex annectens* by C. Davis).

Figure 2. Habitat of *Hyla versicolor.* (Rushes tentatively identified as *Juncus acuminatus* by C. Davis)

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Herbert S. Harris, Jr., Natural History Society of Maryland, Inc., P.O. Box 18750, 6908 Belair Road, Baltimore, Maryland 21206 (hsharris@juno.com).

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News and Notes:

ERRATA

In Gray, B. S. 2013. Observations on litters of Dekay's Brownsnake, *Storeria dekayi* from an urban population in northwest Pennsylvania. Bull. Maryland Herpetol. Soc. 49(1-4):30-39.

The author inadvertently included the following errors:

Pg. 32. In Table 2. The first date should be 13 Aug 03, not 5 Jul 03.

Pg. 33. The earliest litter was 24 July 2012, not 22 July 2012.

News and Notes:

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Baltimore, MD 21206

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